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AUSTRALIA'S BLACK COAL INDUSTRY: PAST ACHIEVEMENTS AND FUTURE CHALLENGES

BART LUCARELLI

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Program on Energy and Sustainable Development

Encina Hall East, Room E415

Stanford University

Stanford, CA 94305-6055

<http://pesd.stanford.edu>

About the Author

Bart Lucarelli is a consulting research associate at the Program on Energy and Sustainable Development at Stanford and an independent energy consultant with 28 years of energy industry experience. He has spent 20 of those years working in Asia with an emphasis on the development of independent power projects and the procurement of secure and cost-competitive supplies of fossil fuels for new power plants. He currently operates an energy consulting business in the region with clients ranging from private power developers to government energy planning agencies. A considerable amount of his work over the past four years has involved helping private power companies and lending institutions assess Asia's coal export markets and assisting private power companies with the procurement of reliable and competitively priced supplies of coal for new coal-fired power plants. He is a frequent speaker at energy conferences throughout Asia and conducts a very popular region-wide seminar on coal pricing and coal supply contracting.

Over the past two years, with PESD support, Bart has been researching the development histories of the Indonesian and Australian coal industries. He has focused his research on the impacts that political and regulatory factors have had on the growth, structure, and performance of those two industries. He is also using his PESD research to speculate on alternative futures that those two industries will face in a carbon-constrained world. Bart has a PhD from the Department of City and Regional Planning at UC Berkeley with a specialty in energy planning. He and his wife, Pornthip, live in Bangkok, Thailand with their three sons, Romeo, Leonardo, and Valentino.

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Australia's Black Coal Industry: Past Achievements and Future Challenges

Bart Lucarelli

Abstract: This paper reviews the technical, economic, political, and regulatory factors that have shaped the black coal industries of Queensland and New South Wales (NSW) over the post-WWII period. It also assesses the factors which are expected to shape the black coal industries of Queensland and NSW over the next 20 years. Its purpose is to document the critical challenges facing the black coal industries of Queensland and NSW and describe the likely futures that might emerge from the resolution of those challenges over time.¹

¹ The author would like to thank the following individuals for their assistance in preparing this paper: Richard Morse of PESD for conducting multiple reviews of earlier drafts of this paper and offering very insightful comments and suggestions that greatly improved the quality of this paper; Mark Thurber also of PESD for the very detailed comments that he provided to an early draft of this paper; Mike Friederich, a consulting coal geologist from Brisbane, Australia, who provided many insights into the coal mining industries of both Queensland and NSW; Pat Markey, chief operating officer for globalCOAL for his very helpful review of earlier drafts of the paper; Cliff Mallett of Carbon Energy for arranging a visit to Carbon Energy's Bloodworth UCG demonstration site in Queensland; and Rhonda Dublewicz, Carol Mische, Peter Thurgood and James Belov at Coal Services Pty. Ltd. for providing information on coal production, exports and domestic consumption, labor productivity and other measures of performance for Australia's black coal industry for the period 1947 through 2008.

1. Introduction

1.1 Background

Any discussion of Australia's black coal industries must focus on the coal industries of Queensland and New South Wales. There are good reasons for focusing on only those two states.² Ninety-six percent of Australia's economically recoverable black coal resources of 39.2 billion tonnes (bt)—commonly referred to in Australia as economic demonstrated resources or EDR—are located in Queensland (56 percent) and New South Wales (40 percent). Almost all of Australia's production and 100 percent of its black coal exports came from those two states in 2008.³

Moreover, Australia's state governments are given wide control over the planning, development, extraction, and sale of coal and other mineral resources. They also have regulatory control over the rail and port industries that provide the inland transport services for moving coal to both domestic and export customers.⁴ In short, Australia's state governments are the nexus where public-private interfaces occur and the states of New South Wales (NSW) and Queensland are where all the black coal is. This paper, therefore, focuses on the black coal industries of Queensland and New South Wales (NSW), which we refer to collectively as the "Australia's black coal industry."⁵

Although the paper's focus is on the steam coal industry, in the case of Australia, the current structure and the past development history of Australia's black coal industry do not allow one to separate the steam coal segment of the industry from its coking coal sibling. The interrelationships between these two industry segments are simply too strong to be ignored.

² Black coal is defined as all coals with a rank of bituminous and anthracite, whether used for generating steam for generating electricity and process heat for industry or for making iron and steel.

³ Source: Geoscience Australia Canberra, "Australia's Identified Mineral Resources, 2009," Table 1, p. 5 and pp. 14-15. Geoscience Australia also claims that Australia has 6 percent of the world's recoverable black coal EDR in 2008 and ranks sixth behind the United States (31 percent), Russia (21 percent), China (13 percent), India (8 percent), and South Africa (7 percent). Geoscience Australia also ranks Australia as the fourth largest producer of black coal in 2008 behind China (45 percent), United States (18 percent), and India (8 percent).

⁴ The one notable exception to this statement is the regulation of greenhouse gas emissions, which may eventually be regulated under a scheme known as the carbon pollution reduction scheme (CPRS) that the current Labor-controlled Commonwealth (national) government hopes to eventually pass into law and mining sector taxes. These two topics are covered in a later section of this paper.

⁵ Australia also has a sizable brown coal industry, which is located in the state of Victoria. Geoscience Australia estimates brown coal EDR at 37.2 billion tonnes, representing a resource life of 490 years at 2008 production levels. (Source: Geoscience Australia, Canberra, "Australia's Identified Mineral Resources," 2009, p. 21.) Australia's brown coal industry and its CO₂ emissions problem are not discussed in this article but clearly worthy of a separate paper on the issue of brown coal utilization and its future in a carbon constrained world.

In particular, development of the large coking coal deposits of the Bowen Basin in Queensland and the Hunter Valley in NSW were found to be the driving force behind the industry's export-led expansion during the period 1950-1985. The development of the massive Bowen Basin and Hunter Valley coking coal deposits was accompanied by large investments in related rail and port infrastructure that, between 1980 and 2000, supported the rapid development of steam coal deposits in both states. In short, Australia would not at this time have a steam coal industry of such scale and capability without the initial development of the coking coal industries of NSW and Queensland (see Box 1 for definitions of coal types covered in this paper).

Most industry analysts are forecast that over the next 20 years, steam coal will drive the future growth of Australia's black coal industry due to its abundant supply and the fast-growing demand for steam coal as the least cost fuel for power plants throughout Asia. However, new technologies, such as improved methods for identifying, developing, and collecting coal bed methane (CBM) and processes for converting solid coal in situ into a gaseous fuel through a process known as underground coal gasification (UCG), have the potential to radically alter these forecasts. Large-scale application of these advanced coal-to-energy technologies may have other far reaching benefits for Australia's black coal industry such as a reduction in the aboveground, visual and land use impacts in comparison with traditional open-cut and underground mining processes.

In time, these advanced coal-energy extraction methods may provide Australia's black coal industry with a much needed diversification of both sources of supply as well as the types of energy products produced from Australia's black coal resources.⁶ Indeed, both regulatory and technical factors—both within and outside of Australia—may reshape Australia's black coal industry over the next two decades in much the same way that the Industrial Revolution of the 18th and 19th centuries led to the widespread use of coal in the UK, Europe, and the United States.⁷

⁶ For example, CBM and UCG may shift the mix of energy products derived from Australia's black coal resources from solid fuel products to gaseous and liquid fuels. This move away from solid fuel emphasis to a mix of gases, liquids, and solid fuels may be encouraged by both domestic and international policies for reducing greenhouse gas (GHG) emissions and increased sensitivity of local communities to the environmental (visual, water, and air) impacts of open-cut mining.

⁷ The author intends to publish a longer monograph of this paper, which will include historical details for the period 1797 to 1947.

Box 1.1: Coal Definitions and Terminology

Black coal resources and reserves are classified in this paper largely according to definitions adopted by the Australia's coal industry and its Commonwealth and state governments, which classify bituminous, anthracite, and sub-bituminous coals as **black coals** with lignite grade coals classified as **brown coals**.⁸ Black coals are used for a larger variety of applications. Power generation is by far the largest of those end uses, accounting for more than 85 percent of total domestic consumption of black coal in 2008.⁹

In a departure from nomenclature adopted by ABARE (Australian Bureau of Agricultural and Resource Economics) and other Australian government entities, black coals used in the steel making industry and for making coke are referred to as **coking coals** (sometimes also called metallurgical coals) of which there can be three primary types: **hard coking coals**, **soft coking coals**, and **semi-soft coking coals**.

A fourth type of coal used in the steel making industry is known as **PCI (pulverized coal injection) coal**. PCI coals are low volatile matter steam coals without coking properties. As such they have qualities that make them very similar to steam coals. However, PCI coals are used primarily for steel making (for which they earn a premium), and due to their low volatile contents, they are not preferred coals for generating power. The production and sales of PCI coal tend to be classified under the coking coal category. Coals used in the power and other industries for raising steam are referred to as **steam coals** as opposed to either thermal or steaming coal, which are the names used by ABARE and Coal Services Pty., Ltd., respectively. The terms adopted in this paper are consistent with International Energy Agency (IEA) terminology for such coals.

⁸ Brown coals, which are not discussed in this paper, have very low energy contents — less than 4200 kcal/kg (gar) and either very high ash contents (>30 percent) or very high moisture contents (>35% and <60 percent), which have in the past made them unacceptable coals in most if not all export markets. Brown coals are used mostly for generating electricity in Australia with a small amount used for making briquettes. In addition to following the above-mentioned coal rank terminology, coal producers in Australia report their resources and reserves according to JORC 2004, which is short for "The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves: The JORC Code, (2004 edition)." The organization that issues the JORC Code also provides updated guidelines on applying the JORC Code to specific cases. These updates as well as the original 2004 JORC Code are available online from www.jorc.org.

⁹ Data supplied to the author by Carol Mische of Coal Services Pty., Ltd. by e-mail in 2010 prior to publication of "2008 Australian Black Coal Statistics."

Black coal statistics for Australia are expressed in a number of distinct ways. The first figure usually cited is raw coal or run-of-the-mine production. Raw coal refers to coal as it is produced at the mine site before washing and other methods of beneficiation. After washing and beneficiation, coal is then classified as “saleable black coal,” which in any particular year can be exported, sold into the domestic market, or added to end of the year stocks at the mine site, export ports, or the sites of domestic customers. In this paper, all references to coal production are to saleable coal production unless otherwise noted as raw coal production.

1.2 Organization of Paper

This paper has four sections.

1.2.1 Post-WWII History of Australia’s Black Coal Industry

(1948-2009) discusses the technical, economic, price, and regulatory factors that have influenced the development of Australia’s black coal industry from 1948 to 2008.

1.2.2 Future Challenges and Issues reviews four critical issues that the paper argues will largely determine the future size and structure of Australia’s black coal industry:

- 1) The availability of economic demonstrated reserves, or EDR, in Queensland and NSW to support continued growth of Australia’s black coal exports, with specific consideration of new coal resources proposed for development in the Surat and Galilee coal basins in Queensland and the Gunnedah Basin in NSW.
- 2) The likelihood that Queensland and NSW will overcome transportation infrastructure constraints and succeed in increasing future steam coal exports through the timely and cost-effective expansions of their rail and port systems.
- 3) The impact on Australia’s black coal industry of the evolving legal and regulatory frameworks of NSW and Queensland, most significantly the Commonwealth government’s proposed carbon pollution reduction scheme (CPRS) and its proposed mineral resources rent tax (MRRT).

1.2.3 New Technology to the Rescue? analyzes how key new technologies might respond to the major challenges facing Australia’s coal industry:

- 1) The impacts that new technologies such as carbon capture and sequestration (CCS), coal bed methane (CBM) extraction and underground coal gasification (UCG) might play in altering the future development of Australia's black coal industry and the mix of energy products produced from Australia's black coal resources.¹⁰

1.2.4 Into the Future synthesizes the above analyses and offers two alternative black coal futures for Australia with some commentary about likely changes to the structure of the coal industry and new energy products that may be available from Australia's black coal industry over the next two decades.

¹⁰ Recent technological advances for finding and extracting coal bed methane (CBM) deposits allow for the economic extraction of gaseous fuels from steam coal deposits, which are either "at depth," i.e., depths that are not economically feasible to mine either by open-cut or underground mining methods, or are located very far from existing rail and port infrastructure. Underground coal gasification (UCG) is experiencing a similar degree of technological advance, which may lead to a restructured black coal industry in which the mix of energy products will shift from multiple solid fuel products to a mix of solid, gaseous, and liquid fuels and where the extractable energy resource base can be increased by a factor of three or more.

2. Post-WWII History of Australia's Black Coal Industry (1948-2009)

The history of Australia's black coal industry can be conveniently broken into (a) the early years period, which starts in 1797 and ends in 1947, and (b) the post-WWII period, which starts in 1948 and ends in 2009. This paper focuses on the post-WWII period and analyses the history of Australia's black coal industry as four discrete development phases:

- The Recovery Phase (1948-1959)
- The Rapid Growth Phase (1960-1986)
- The Competitive Phase (1987-2003)
- The Volatile Price Phase (2004-present)

Figure 1 presents the annual saleable black coal production levels for Queensland, NSW, and other states over the post-WWII period for each of the four development phases.¹¹ Between 2004 and the present, black coal prices have entered a new phase, which for lack of a better term, is referred to as the volatile price phase, because it has been categorized thus far by chronic transportation infrastructure shortages, higher costs of extraction and transport, strong demand for steam coal from China and India, and severe price volatility. This phase is expected to continue until at least 2015.

2.1 The Recovery Phase (1948-1959)

The recovery phase of the post-WWII period was a time when the Australian black coal industry transformed itself from an inefficient and unreliable supplier of coal into an industry that would eventually become the world's largest and most efficient exporter of high-quality coking and steam coal. Prior to WWII, Australia's black coal industry was thoroughly dominated by the coal industry of NSW. In those days, regulations were few and those that did exist were either weakly enforced or ignored by industry and labor unions. The result was cut-throat competition and frequent strikes and other acts of industrial strife that led to frequent

¹¹ Most of the production and export data referred to in this paper have been obtained from official reports published by Coal Services Pty. Ltd. and its predecessor, the Joint Coal Board. The data provided are fiscal year data. For the sake of brevity, each FY is expressed as the starting year of that fiscal year. As an example, FY 1960/1961 is referred to as 1960. The latest Coal Services Pty. Ltd. coal statistics report covers FY 2008/2009.

disruptions in NSW's black coal supplies and eventually the destruction of its budding coal export business.¹²

2.1.1 Increased Regulatory Control

During WWII, the Commonwealth government passed a number of laws with the objective of ensuring a reliable supply of coal in support of the war effort.¹³ As part of these legislative initiatives, the Commonwealth government created the Commonwealth Control Board (Feb 1941) to resolve labor-management disputes at an early stage. This commission was apparently a failure as it was soon replaced by the Conciliation Commission in November 1941.¹⁴

In May 1942, the Commonwealth government convened a special conference in Canberra with mine owners and labor unions representing coal miners as participants. The attendees agreed to protocols for resolving labor-management differences. The resulting agreement, known as the Canberra Code, included commitments from all parties to settle disputes amicably without engaging in strikes. It did not hold up. Shortly after signing the Canberra Code, new labor disputes occurred at frequent intervals, leading to significant disruptions of coal supply to industry. The growing number of management-labor disputes was partly due to the fragmentation of the Miner's Federation, which controlled the labor force in the black coal industry. During the war years, this union was divided into communist and non-communist factions, which attempted to outdo each other with respect to their salary and other demands.¹⁵

The Commonwealth and state governments did not help matters by largely conceding to the demands of the unions in the interest of ending strikes and keeping the coal supply flowing. Reasonable government concessions, such as the establishment of a miner's pension fund and rescinding prior penalties imposed on striking miners, were viewed by the unions as a sign of weakness and only served to encourage the unions to engage in more work stoppages.¹⁶

Despite the Commonwealth government's many good faith efforts to resolve labor disputes in the coal industry amicably, the WWII period was one "characterised by near critical shortages

¹² See Shaw, A.G.L., and G.R. Bruns, "The Australian Coal Industry," Melbourne University Press, 1948, pp. 1-3 and Joint Coal Board, "First Report of the Joint Coal Board: March 1, 1947 to June 30, 1947 and 1947-1948," Government Printer, Sydney, NSE, 1948, pp. 6-7.

¹³ Productivity Commission, 1998, "The Australian Black Coal Industry" Inquiry Report, AusInfo, Canberra, vol. 2, Appendix E, p. E2 and Box E-1, p. E-3.

¹⁴ Ibid.

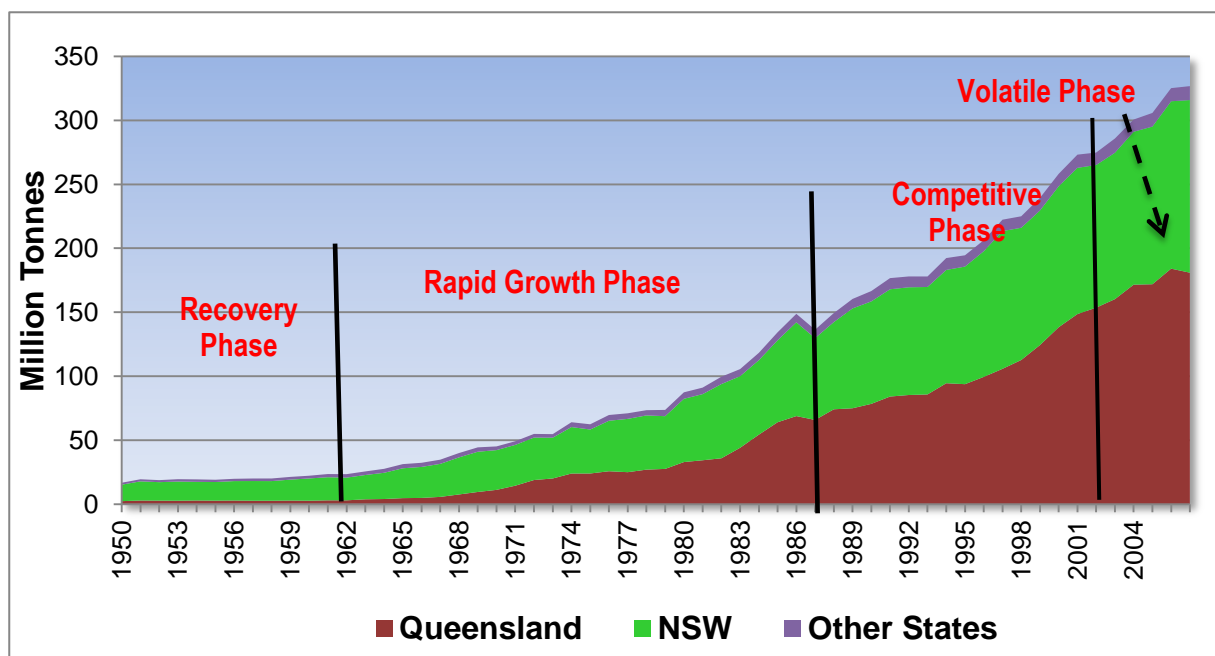
¹⁵ Ibid.

¹⁶ Ibid.

of coal for Australia's war effort and near disastrous levels of industrial disputation in the black coal industry."¹⁷ The loss in coal output during WWII due to labor strife was estimated at 23percent of potential production.¹⁸

Eventually, the Commonwealth government's ad hoc and largely ineffective war-time powers over the coal industry were subsumed into the Coal Production (War-Time) Act of 1944, which established a "Commonwealth Coal Commissioner with wide powers to take control of any coal mine and distribution networks in the interest of supporting the nation's war effort. The Coal Commissioner also had broad authority to set coal prices throughout Australia."¹⁹

Figure 1: Saleable Black Coal Production 1950-2008 by State (million tonnes)



Source: Joint Coal Board, "Black Coal in Australia," 1986-87, January 1988, Table 134, p. 127.

When the war ended, the Commonwealth and NSW governments decided not to allow unfettered free enterprise to re-emerge in the NSW coal sector.²⁰ Their justification for establishing greater regulatory control over the NSW coal industry was the precarious state of the industry at the close of WWII—with exports practically non-existent and the domestic

¹⁷ Ibid.

¹⁸ Ibid.

¹⁹ Joint Coal Board, "First Report of the Joint Coal Board: March 1, 1947 to June 30, 1947 and 1947-1948," Government Printer, Sydney, NSE, 1948, p. 4.

²⁰ Official Year Book of the Commonwealth of Australia, No.37, 1951, p. 877.

power, town gas, rail transport, steel making, and cement industries clamoring for a more reliable and lower cost supply of coal. Coal shortages after WWII were expected to have serious adverse effects on Australia's post-war reconstruction, which depended heavily on adequate supplies of iron and steel products, building materials, and transport.²¹

To address these concerns, the Commonwealth government passed the Coal Industry Act (No.40 of 1946) and the NSW government passed the Coal Industry Act (No. 44 of 1946). Both laws took effect in 1946 and are commonly referred to as the joint acts. Under the joint acts, the Commonwealth and NSW governments established the Joint Coal Board (JCB) and the Coal Industry Tribunal (CIT), which was given broad powers to determine wage levels and working conditions “for the majority of employees in the NSW black coal industry, as well as Queensland and Tasmania by virtue of the Commonwealth Act.”²² The CIT also subsumed authority over all coal industry worker issues that was previously held by the Commonwealth government’s Industrial Relations Commission and the NSW government’s Industrial Commission of New South Wales. The joint acts had almost identical provisions, except for powers allowing the JCB to control coal collieries and take over their assets and operations on a compulsory basis. These provisions were contained in the NSW Coal Industry Act only.

The passage of the joint acts transformed the pre-war regulatory setting for the NSW coal industry from one based almost totally on laissez-faire principles to one in which the Commonwealth and NSW governments would play a strong role in regulating and rehabilitating its black coal industry.²³ Before the JCB and the CIT could exercise their powers and make a difference, however, the Communist Party of Australia and its supporters within the more radical labor unions launched the 1949 coal strike, which shut down the NSW’s coal industry for seven weeks. Eventually, the Labour governments of NSW and the

²¹ Joint Coal Board, “First Report of the Joint Coal Board, March 1, 1947 to June 30, 1947 and 1947- 1948,” pp. 6-7.

²² Productivity Commission, 1998, “The Australian Black Coal Industry” Inquiry Report, AusInfo, Canberra, vol. 2, Appendix E, p. E4.

²³ In 1948, the State of Queensland established the Queensland Coal Board with powers roughly similar to those of the Joint Coal Board. However, Queensland did not seek Commonwealth involvement in the form of joint coal industry acts. Victoria and South Australia also determined that they did not need to involve the Commonwealth government. Instead they asked that they be exempted from the still active Coal Production (War-Time) Act of 1944, which the Commonwealth government did. Surprisingly, the Coal Production Act of 1944 appears to have remained in force until the 1960s, albeit without the coal commissioner, which discontinued its operations in 1947.

Commonwealth crushed this strike and the radical unions by passing and implementing emergency legislation that led to the jailing of many of the strike's leaders.²⁴

The JCB and the CIT eventually played pivotal roles in neutralizing the more radical unions and removing labor unrest as a development issue for the black coal industry during the 1950s. A key component of their success was taking an active role in improving the working conditions in underground mines and the infrastructure of mining communities.

The actions of the JCB and the CIT effectively neutralized the industrial dispute and work stoppage situation in NSW, which had been a major impediment to the growth of Australia's black coal industry. This is not to say that work stoppages and labor-management disputes did not flare up during the post-war period. On the contrary, during the 1970s and 1980s, disputes were once again the primary reasons for lost output from Australia's black coal mines.²⁵ However, the losses, while significant, never threatened the overall reliability of coal supply as had events prior to 1950.

Although the joint acts paid lip service to the notion of "private ownership and operation of coal mines," the early emphasis of the JCB was on increased state control and intervention. In particular, the joint acts authorized the JCB to take over the operations of inefficient coal mines, as well as supporting enterprises, to ensure that "coal produced in NSW was available in such quantities and with such regularity as will meet requirements throughout Australia and in trade with other countries."²⁶

In response to this mandate, the JCB owned and operated collieries (coal mines) in NSW from 1947 (its first year of operations) until March 1957. Its share of total raw coal production ranged from 5 percent in 1947 to a peak of 16 percent during 1951.²⁷ Between 1950 and 1954,

²⁴ See Kim Bullimore, "1949 Coal Strike: Labour's 'boots and all' sell-out" (www.greenleft.org.au) for a less than flattering analysis of Australian government's response to 1949 coal miner strike and the events that eventually led to the decline of union power over the coal industry after WWII. Also see Phillip Deery (ed.), "Labour in Conflict: The 1949 Coal Strike," Hale and Iremonger, Sydney, 1978.

²⁵ Productivity Commission, 1998 "The Australian Black Coal Industry" Inquiry Report, AusInfo, Canberra, vol. 2, Appendix E, p. E5.

²⁶ Ibid, page 5. The JCB, which had the power to take over the operations of inefficient coal mining companies, took control of a number of underperforming collieries during its first 20 years of existence, some of which were transferred to it by the Commonwealth Coal Commissioner's Office in 1947.

²⁷ Joint Coal Board, various issues of its annual report for 1947 through 1957.

JCB-owned mines supplied more than 10 percent of NSW raw coal production.²⁸ Eventually, after much prodding from the Commonwealth government, the JCB, in March 1957, sold off its ownership in three NSW coal mining companies and, with those divestments, the JCB ended its joint role as black coal regulator and coal producer in NSW.²⁹

The divestment decision was certainly helped along by a major financial scandal that affected the JCB's accounting department in 1949.³⁰ The JCB board of directors uncovered matters of gross negligence and managerial incompetence within its accounting department related to the operations of the JCB-owned collieries. The JCB board described the situation as "a complete breakdown in the accounting section which was no longer able to present an authentic statement of the Division's activities."³¹ The JCB also noted that the accounting department's "reports and cost statements were not being presented on the due dates and information in reports that had been received was subsequently found to be unreliable and, in some cases, completely misleading."³² As a result of these financial irregularities, the JCB suffered a significant loss for that time of £350,441.³³

Unsurprisingly given the history of labor disputes, during the late 1940s and the early 1950s and this financial scandal within the JCB, many industry analysts held a very pessimistic view about the future of Australia's black coal industry with a number of analysts predicting its demise due to labor unrest.³⁴ Others called for its nationalization to protect the public interest.³⁵ In retrospect, the 1950s turned out to be a time when miners and mine owners, with JCB prodding, reached a point of peaceful co-existence, which supported the industry's recovery and subsequent expansion.

2.1.2 Production and Market Trends

During the recovery phase, growth in saleable production was modest. Figure 1 (above) illustrates the slow growth in production during the recovery phase relative to growth in production experienced during the later rapid growth and competitive phases. In 1950, saleable

²⁸ Ibid.

²⁹ Joint Coal Board, "Eleventh Annual Report for the Financial Year 1957-1958," pp. 32-33

³⁰ Joint Coal Board, "Third Annual Report for the Financial Year 1949-50," pp. 17-18.

³¹ Ibid.

³² Ibid

³³ Ibid.

³⁴ Shaw and Bruns, pp. 170-181

³⁵ Ibid.

production of black coal for all of Australia stood at only 16.8 million tonnes (mt). By 1959, saleable production increased to 19.8 mt, representing a compound annual growth rate (CAGR) of only 3.2 percent. Most of the production was from NSW, which accounted for 77 percent of Australia's saleable black coal production over the period 1950-1959, with Queensland accounting for 14 percent of saleable production and other states for the remaining 9 percent.³⁶

The coal production mix began to shift during this time period. The primary coal product in 1950 was steam coal, which accounted for 82 percent of total coal sales. By 1959, steam coal sales dropped to 72 percent of total black coal sales as coking coal emerged as the Australian black coal industry's fastest growing market. The decade of the 1950s was also a time when the domestic market was the dominant source of demand for Australia's black coal with domestic uses of coal accounting for 99 percent of 1950 coal sales.³⁷ By 1959, domestic consumption still accounted for 94 percent of total sales, although exports were finally starting to show signs of recovery. Starting from an extremely low base of 68,000 tonnes in 1950, exports grew by 38 percent per annum over the 1950s, reaching 1.2 mt by 1959.

2.1.3 Role of New Technology during the Recovery Phase

Until 1935, coal mining in Australia was largely a manual operation, based on two-man teams equipped with picks, shovels, and hand-push trolleys and, in some cases, wheelbarrows, to remove coal from coal seams and transport it to the surface. In deeper mines, the coal was dumped from the trolleys and wheelbarrows at the bottom of a vertical shaft and then hoisted to the surface in buckets by winch.³⁸

At the start of the recovery phase, the Australian black coal industry was woefully under mechanized when compared with the coal industries of other coal-producing nations.³⁹ Moreover, most coal mining companies in those early days did not have strong enough balance sheets and technical capabilities to mechanize their mines. The JCB recognized this industry deficiency from the outset and implemented programs to encourage companies to mechanize

³⁶ Joint Coal Board, "Black Coal in Australia, 1980-81," March 1982, Table 4, p. 11.

³⁷ Domestic consumption in 1950/1951 was greater than 100 percent of total saleable production for that same year, indicating that coal stockpiles were drawn down to meet the strong domestic demand in that fiscal year.

³⁸ Australian Academy of Technological Sciences and Engineering, "Technology in Australia 1788-1988: A condensed history of Australian technological innovation and adaptation during the first two hundred years," p. 758 (Chapter 11, Coal Transition at the Coal Face) 2000 (online edition), (available online: www.austehc.unimelb.edu.au/tia/758.html).

³⁹ Joint Coal Board, "Fourth Annual Report, 1950-51," p. 15.

their operations and regulations to punish those that did not.⁴⁰ These incentives and supports included free technical assistance to mine operators in need of advice on how to plan the future development of their mine sites and financial assistance in the form of loans and even grants to those mine operators who chose to purchase equipment for mechanizing their mines.⁴¹

The JCB also established “an equipment pool from which colliery companies could either purchase or hire the most modern types of mining machinery” and provided financial and technical assistance to domestic manufacturers of mining equipment who wanted to diversify into types of mining equipment only available offshore.⁴² The purchase-hire program had an important demonstration effect, which encouraged many other companies to adopt the same equipment as the early pioneers in order to remain competitive in the industry.

As a result of these early JCB programs, the coal mining industry began an aggressive drive to mechanize during the 1950s. This was also a time when the adoption of improved exploration methods and equipment led to significant improvements in the amount of new coal discovered on unexplored tenements.⁴³ Specific improvements in exploration techniques and equipment included the following:

- Development of improved seismic techniques, data logging equipment, drilling rigs, and core lifters
- Improved electro-mechanical instruments and tools
- Advanced instrumentation for monitoring the performance of drills

These technological advances in the field of minerals exploration contributed to the discovery within NSW’s Hunter Valley and Queensland’s Bowen Basin of high-quality, coking coal deposits with low stripping ratios that were amenable to open-cut mining methods. However, it was the application of new mining technologies that drew the most attention as these technologies led to machines displacing labor, which resulted in strong union opposition. Mechanization of the mines had an immediate and visible impact on coal production.

⁴⁰ Ibid, p. 14.

⁴¹ Ibid.

⁴² Ibid.

⁴³ Tenements are those areas subject to mining licenses that are “leased” to some individual or entity for a fixed period of time on commercial terms. A person holding a mining license for a particular area is said to have “tenure” over the land. In Indonesia, tenements are referred to as concession areas.

Prior to the 1950s, mechanization was limited to the use of hand-held machine cutters and picks for cutting the coal from the rock face and for drilling bore holes to place explosives.⁴⁴ In certain instances, winches powered by electricity and steam engines were used to transport the coal out of the mines.⁴⁵ The few new technologies that were adopted were used to partially mechanize underground coal mines, which, during most of the 1950s, accounted for more than 80 percent of Australia's black coal production. Coal produced from Australia's underground mines peaked at 91 percent of total production in 1958 and 1959.⁴⁶

During the recovery phase and for most of the rapid growth phase, mining companies developed their underground mines according to the bord and pillar mining system, which consisted of a series of parallel main tunnels running that intersected secondary tunnels known as cut-throughs, which were driven at right angles to the main tunnels.⁴⁷ The roof of the mine was supported by the pillars of coal as shown in Figure 2.⁴⁸

The bord and pillar system involved removal of the in situ coal in two "workings." The first working involved the extraction of coal from the tunnels followed by the removal of coal in the pillars, which was known as a second working. The percentage of coal left in pillars after completion of the second working was always quite high, at least 50 percent of the total recoverable coal and oftentimes much higher.⁴⁹ Once most of the pillar coal had been extracted from a specific section of the mine, the mine operator allowed the roof to collapse under "controlled conditions," which involved removing the temporary roof supports.⁵⁰

The coal extraction process in both workings needed to happen in four distinct phases: (i) coal cutting; (ii) boring (drilling holes in the coal seam for placing explosives); (iii) shooting or placing and detonating the explosives; and (iv) loading the coal onto wagons for transport out

⁴⁴ Australian Academy of Technological Sciences and Engineering, "Technology in Australia 1788-1988, p. 758 (Chapter 11, Coal Transition at the Coal Face) 2000 (online edition), (available online: www.austehc.unimelb.edu.au/tia/758.html).

⁴⁵ Ibid.

⁴⁶ Joint Coal Board, "Fifteenth Annual Report for the Financial Year, 1961 - 1962," Appendix 13, Table 3, p. 151.

⁴⁷ Joint Coal Board, "Fifth Annual Report for the Financial Year, 1951 - 1952," Appendix II, p. 48.

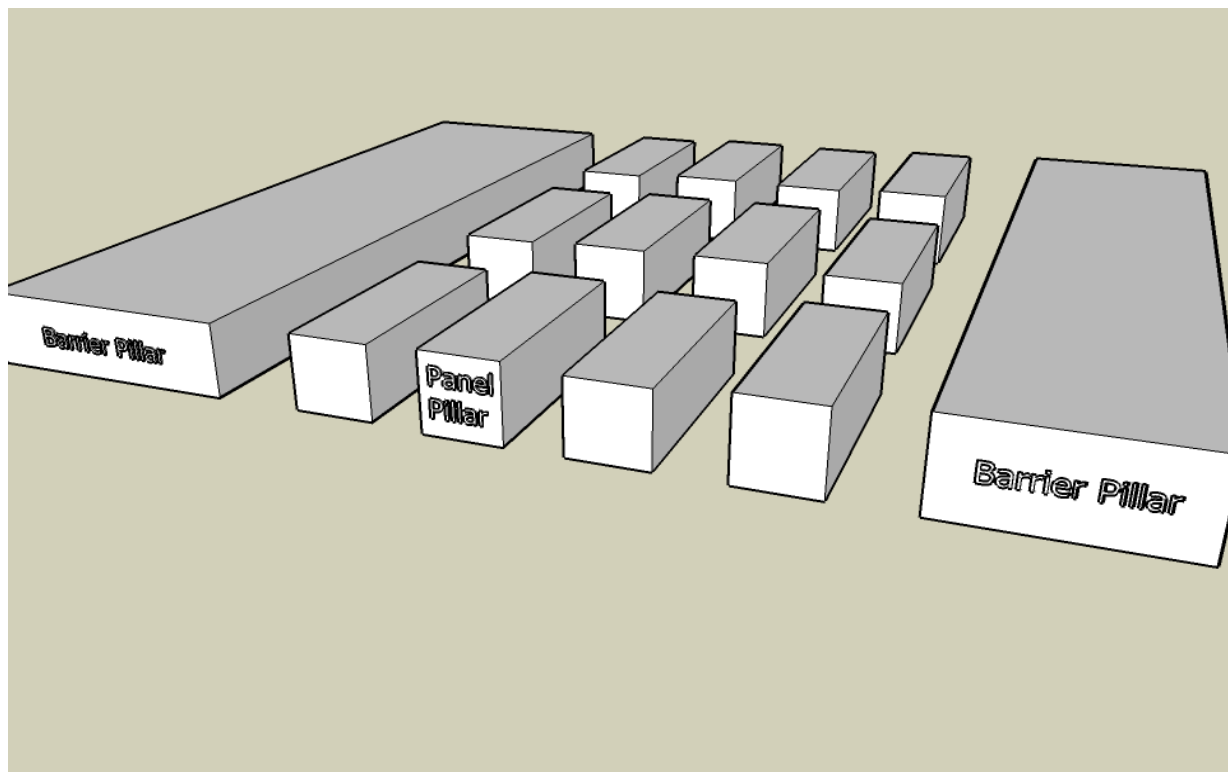
⁴⁸ Another way to visualize a bord and pillar mine is to think of it as a modern city with that city's main roads represented by the main tunnels of the mine and the side roads as the secondary tunnels of the mine. The pillars represent the city blocks. *Australian Academy of Technological Sciences and Engineering*, "Technology in Australia 1788-1988," p. 758.

⁴⁹ Joint Coal Board, "Fourth Annual Report of the Joint Coal Board for the Financial Year 1950-51," p. 21.

⁵⁰ Ibid.

of the mine.⁵¹ Manual cutting, boring, and shooting of coal seams during the first working was very time-consuming, dangerous, and an unproductive use of labor. The manual removal of the pillar coal during the second working was also very dangerous and inefficient.⁵² Although a maximum of 60 percent of the in situ coal could be extracted using bord and pillar methods, the extracted amount was typically much lower when manual methods for removing pillar coal were used.⁵³

Figure 2: Diagram of a Bord and Pillar Mine



Source: www.wikimedia.org.

In 1950, the JCB successfully demonstrated the use of a Joy Continuous Miner at the Huntley Colliery in the Illawara District of NSW.⁵⁴ This advanced mining machine allowed the cutting, boring, and loading phases of bord and pillar mining to be completed as one fully automated

⁵¹ Ibid.

⁵² Ibid, p. 49

⁵³ Longwall mining systems, which were not widely applied in NSW mines until the late 1980s, allow for 60 percent to 80 percent of the in situ coal to be extracted.

⁵⁴ <http://www.illawarracoal.com/technology.htm>

operation.⁵⁵ It also allowed mechanical extraction of coal from the pillars without the use of explosives and with a substantial reduction in the number of miners required per tonne of coal extracted.⁵⁶

The successful demonstration of the continuous miner at the Huntley Colliery eventually led to the lifting of a government-union ban on the mechanical extraction of coal from pillars and the start of multiple shift operations in underground mines, which previously operated on a single shift.⁵⁷ The continuous miners would first cut the coal from the work face of the mined area using a revolving drum head containing concentrically positioned teeth (Figure 3).⁵⁸ The coal would then be moved toward the center of the mine and transported out of the mine.

The use of continuous miners encouraged further mechanization of coal transport from the coal face to the surface of the mine. Initially, the extracted coal was loaded from the continuous miner onto a rubber-tired shuttle car, which would then transport and discharge the coal onto a belt conveyor that would carry the coal to the surface of the mine.⁵⁹ Eventually, shuttle cars were replaced by electric conveyors equipped with steel-cored, non-flammable belts. These conveyors, which were connected to the back of the continuous miners, allowed the extracted coal to be conveyed from the mine face to either the surface of the mine or a central collection area within the underground mine. This transport arrangement allowed continuous miners to be more fully utilized and to achieve the lowest cost of coal extraction and loading.

⁵⁵ Australian Academy of Technological Sciences and Engineering, “Technology in Australia 1788-1988,” p. 759.

⁵⁶ *Ibid.* Continuous miners also allowed the labor reductions by reducing the number of coal faces that needed to be operated, maintained, and ventilated and by allowing a more continuous completion of the cutting, boring, and loading steps of coal extraction.

⁵⁷ *Ibid.*

⁵⁸ Productivity Commission, 1998, “The Australian Black Coal Industry” Inquiry Report, AusInfo, Canberra, vol. 2, Appendix B, p. B7.

⁵⁹ *Ibid.*, p. 762.

Figure 3: Joy Continuous Miners in Action



Source: www.joy.com/Joy/Products/Continuous-Miners).

By the end of recovery period in 1959, 71 continuous miners were in operation in NSW, accounting for 39 percent of NSW's coal production.⁶⁰ The use of continuous miners and other improvements to the methods of underground bord and pillar mining led to very large productivity gains for Australia's underground coal mines during the recovery period.⁶¹ For example, output per man-shift worked (OMS for all employees), a standard measure of coal mine worker productivity in Australia, increased from 2.93 tonnes/OMS in 1950 to 5.13 tonnes/OMS in 1959, or by 75 percent for all NSW underground mines.⁶²

Worker productivity gains of even greater magnitude were achieved for open-cut mines operating in NSW. In 1950, NSW open-cut mines had a worker productivity of 8.55 tonnes/OMS. By 1959, NSW underground mines produced 19.12 tonnes/OMS, a 124 percent

⁶⁰ Joint Coal Board, "Thirteenth Annual Report of the Joint Coal Board for the Financial Year 1959 – 1960", pp. 29-30.

⁶¹ Longwall mining methods, which were not widely adopted in Australia until the 1980s, relied on the use of a specialized mining machine known as a longwall miner, which sheared the coal from a 100 m to 200 m wide work face and deposited it onto a conveyor for transport to the surface. This method of mining allowed for (a) coal recovery rates of up to 80 percent; (b) very high output levels per worker; and (c) improved worker safety relative to bord-and-pillar-mining methods. Sensors used in this process of mining helped detect the amount of coal remaining in the seam while robotic controls enhanced the efficiency of the process. Source: E.M. Warner, "A History of American Continuous Miners" (paper presented at 1979 International Conference on Mining Machines, Brisbane, July 2-6, 1979).

⁶² Joint Coal Board, "Fourteenth Annual Report for the Financial Year, 1960-1961," Appendix 12, Table 22, p. 146

increase over a 10-year period.⁶³ These open-cut productivity gains were achieved with the application of massive electric-powered draglines, large diesel-fuelled trucks, and other pieces of large earth-moving equipment, which provided a more economical process of overburden removal and coal extraction.

Open-cut mining technologies were first applied in Australia in 1937 at the Blair Athol mine in Queensland. In 1940, they were introduced into NSW. The first open-cut mines to operate in NSW were prolific producers of coal, but due to poor advance planning the open pits that were developed during the early 1950s in NSW were rapidly depleted leading to disruptive swings in production. The JCB, in 1954, attempted to limit production from open-cut mines by requiring coal producers to first try to meet their coal orders from existing underground mines. Only after the underground capacity was exhausted were coal producers allowed to rely on open-cut mines for any unmet demand.⁶⁴ As a result of the JCB's ill-advised policy of using open-cut mines as producers of last resort, NSW production from open-cut mines dropped from 1.8 million tonnes (mt) and 14 percent of total NSW production in 1950 to 0.6 mt and 3 percent of total NSW production in 1959.⁶⁵

The folly of this type of technology-limiting policy was soon realized by the JCB and its output restricting policy regarding NSW's open-cut mines was dropped by the late 1950s. Open-cut mining during the subsequent rapid growth phase (1960-1986) became the primary vehicle for growing the black coal industries of NSW and Queensland.⁶⁶ Despite its ill-advised restrictions on open-cut mining, the JCB did arrange for the adoption of advanced open-cut machinery during the 1950s, which resulted in the very large gains in worker productivity cited above for the period 1950-1959.

These technological advances in the methods of both open-cut and underground mining had two important impacts on the Australian coal industry over the period 1950-1959. First, they

⁶³ Ibid.

⁶⁴ Ibid.

⁶⁵ Ibid, Appendix 12, Table 2, p. 127.

⁶⁶ In Queensland, where such restrictions did not apply, open-cut mining methods were fully applied by Utah International and Theiss Brothers, which in the mid-1960s discovered large coal deposits of high-quality coking coal in the Bowen Basin areas of Queensland that were amenable to open-cut mining. By the mid-1970s, Queensland produced 88 percent of its coal using open-cut methods versus 12 percent for NSW. The role played by these advanced open-cut technologies as well as longwall underground mining methods is discussed in more detail under the heading "rapid growth phase." Galligan, Brian, *Utah and Queensland Coal: A Study in the Micro Political Economy of Modern Capitalism and the State*, University of Queensland Press, 1989, pp. 126-127.

contributed to the decline of labor union power at the coalmines of NSW and Queensland by reducing the need for unskilled and semi-skilled labor in both underground and open-cut mines. The advanced machines and methods also required improved technical skills of the remaining labor force. The skilled workers were paid higher salaries and provided with improved working conditions and benefits.

The improved pay and working conditions led to reduced labor-management tensions and a huge reduction in lost output due to industrial work stoppages in NSW (Figure 4). Production losses due to industrial work stoppages, which stood at 1.7 mt and 11 percent of possible production had, by 1959, been reduced to a relatively small amount—less than 600,000 tonnes and 3 percent of possible production.⁶⁷ By the close of the recovery phase, industrial work disputes were no longer seen as a threat to the survival of NSW's black coal industry.⁶⁸

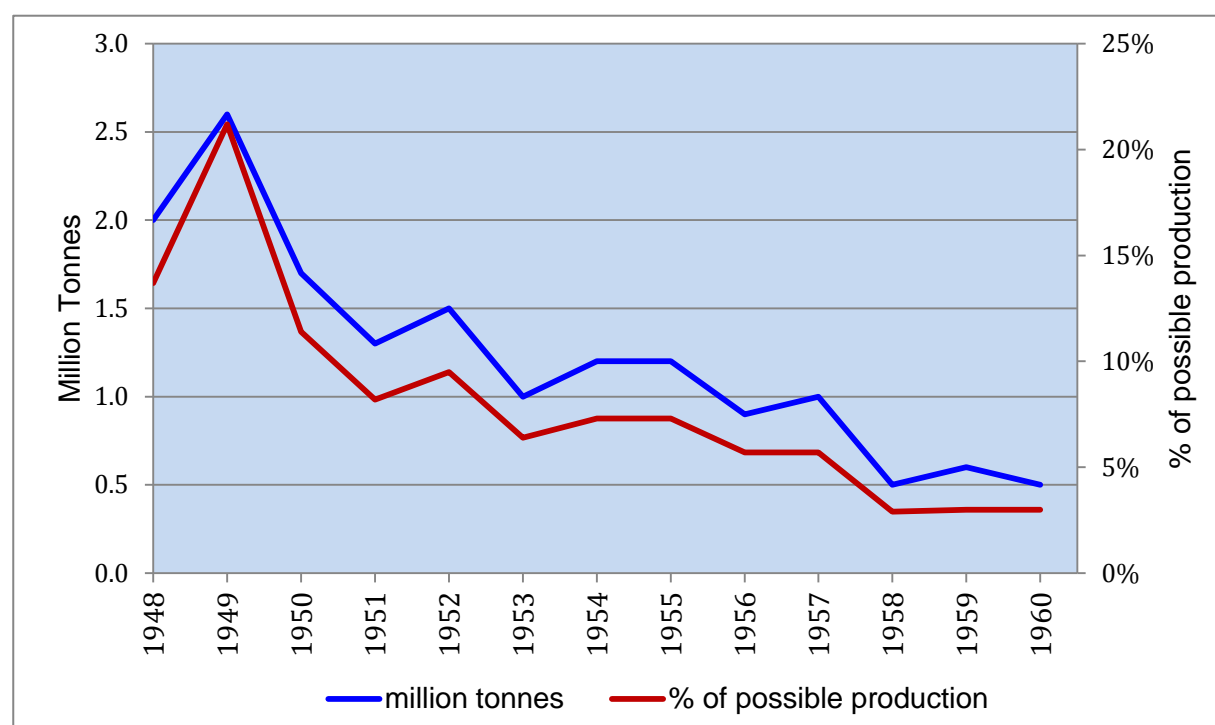
The application of advanced mining technologies also resulted in substantial reductions in costs of production that, in turn, allowed Australian black coals to compete in international markets, which in turn justified the expansion of rail and port infrastructure in both NSW and Queensland. Because export markets were growing simultaneously with the expansion in mine capacity, the industry was able to expand its output without causing a price collapse.

With respect to transportation infrastructure, the 1950s was a time when diesel- and electric-powered locomotives started to displace coal-fired locomotives. During the 1950s, the Port of Gladstone was transformed from a port that catered to declining primary industries, such as cattle and other agricultural products, into a coal export center. Today, Gladstone is the second largest coal export port in Australia (Newcastle remains the largest). But it was not until the 1970s that Gladstone and Newcastle were expanded into world-class coal shipping ports. These developments are discussed below under the heading “Rapid Growth Phase.”

⁶⁷ Joint Coal Board, “Fourteenth Annual Report for the Financial Year, 1960-1961,” Appendix 12, Table 26, p. 150.

⁶⁸ Ibid, p. 33.

Figure 4: Lost Output Due to Industrial Work Stoppages at NSW Coal Mines, 1948-1960
(in million tonnes and percent of possible production)



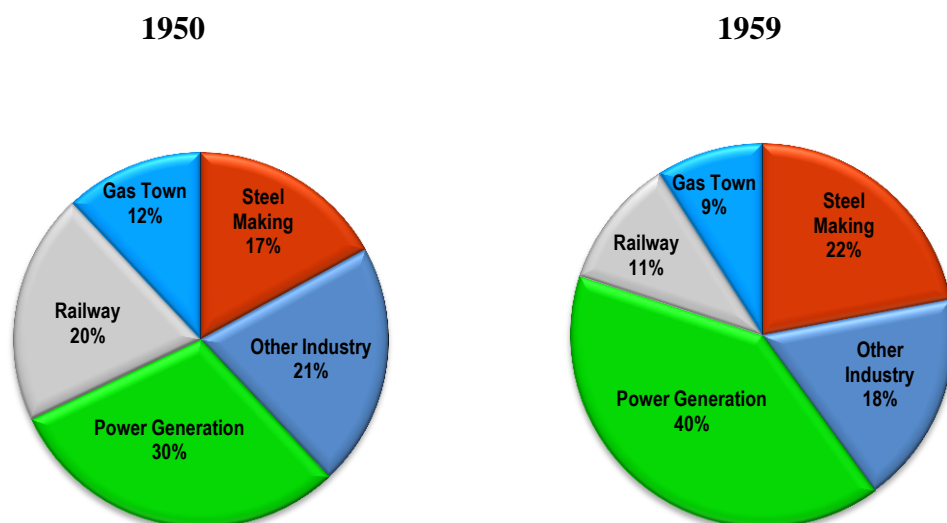
Source: Joint Coal Board, “Fifteenth Annual Report of the Joint Coal Board for Financial Year 1961-62,” Tables 27 and 28, pp. 174 and 175.

2.1.4 Evolution of the Domestic Market

During the recovery phase, the domestic markets for coal started to transition away from the shipping, railway, and town gas industries to the electric power and steel making industries (Figure 5).⁶⁹ The demise of the coal bunker fuel market was already a *fait accompli* by 1950, with the small remaining amount of bunker fuel used to fuel ships limited to those plying interstate trade in Australia. The beginning of the end for the rail and town gas industries was also noticeable by 1959 (Figure 5). Given that coal producers of NSW and Queensland were just beginning to re-establish themselves in the export markets by the end of the 1950s, the growth in the domestic power and steel making markets for black coal offset the declines in coal usage in the rail and town gas industries.

⁶⁹ The Official Year Book of the Commonwealth of Australia: No.42, 1956, p. 1012. Between 1941 and 1946, railway locomotives were the biggest domestic consumers of black coal. Over this period, railways accounted for 23 percent of domestic black coal consumption versus 20 percent for the power sector, 13 percent for the town gas industry, 2 percent as bunkers used by the shipping industry. From 1947 onward, the power industry was the largest single consumer of black coal in Australia.

Figure 5: Share of Black Coal Consumption by Industry, 1950 and 1959



Source: Australian Official Yearbook, #42, 1956, p.1012. Joint Coal Board, 16th Annual Report, 1962-63, p. 68.

2.2 Rapid Growth Phase (1960-1986)

Between 1960 and 1986, the Australian black coal industry achieved an astonishing 26 years of uninterrupted rapid growth (Figure 1). It also diversified its sources of supply, its export customers, and its coal products during this phase of development. The CAGR of saleable production for this phase was 8 percent per year with production increasing from 22.2 mt in 1960 to 148.7 mt in 1986.⁷⁰ Another important development was the emergence of Queensland as the Australia's largest exporter of black coal in 1972 and its largest producer of "raw" black coal in 1985.⁷¹

The strong growth of Australia's black coal industry can be attributed to continued improvements in mining technology and the rapid growth of the Japanese export market for coking coal. During the rapid growth phase, the continued mechanization of mines and the growth of open-cut mining relative to underground mining drastically improved efficiency and boosted production while manual mining was phased out. At the start of the rapid growth phase in 1960, the JCB had successfully mechanized the bord-and-pillar-type mines in NSW with 90 percent of all coal production coming from fully mechanized mines (both winning and

⁷⁰ Joint Coal Board, "Black Coal In Australia, 1986-87," Table 8, p. 14.

⁷¹ Ibid, Tables 7 and 100, pp. 13 and 97.

loading of coal was by mechanized means of some sort). A more important measure of mechanization was the increased use of continuous miners. In 1960, continuous miners were used to “cut” 37 percent of NSW’s underground coal production.⁷² By June 1966, NSW had increased the number of operating continuous miners to 146, which the JCB estimated, based on a one-month production study, accounted for 87 percent of NSW’s underground coal production.⁷³ The speed at which the NSW coal industry had mechanized its operations was even more impressive if one considers that the U.S. coal mining industry relied on continuous miners to produce only 25 percent of its 1960 coal production.⁷⁴

2.2.1 Further Advances in Underground Mining Methods

However, there was still more to come. Over time, the JCB and coal mine owners discovered that continuous miners were not as continuous as their name implies. A continuous miner must stop operating frequently to allow an empty shuttle car to “berth” next to it after the loaded shuttle car departed.⁷⁵ It also needed to stop operating during times when roof supports had to be put in place and when moving from tunnel to tunnel. It was found that even under optimal conditions with conveyors used for moving the coal to the surface, a continuous miner operated only 50 percent of the available time at the coal face.⁷⁶ In addition, a continuous miner could work only around 50 meters along the coal face before it needed to be moved to a new location.⁷⁷ Finally, removing the pillars with a continuous miner, although safer than doing the job manually, still posed risks to the eight-man crew working the continuous miner, which became a growing safety concern over time.⁷⁸

In response to the factors affecting the efficient utilization of a continuous miner and its inherent safety risks, mine equipment manufacturers in the UK turned their attention to the design of a new underground mining system that could achieve almost 100 percent continuous operation with an improved level of worker safety. The final design concept, which was later branded as the longwall mining system, consisted of hydraulic roof support assemblies to

⁷² Joint Coal Board, “Fourteenth Annual Report, 1960-1961,” Appendix 12, Table 34, p. 160.

⁷³ Joint Coal Board, “Nineteenth Annual Report for the Financial Year 1965-66,” p. 30.

⁷⁴ Ibid.

⁷⁵ Australian Academy of Technological Sciences and Engineering, “Technology in Australia 1788-1988,” p. 760.

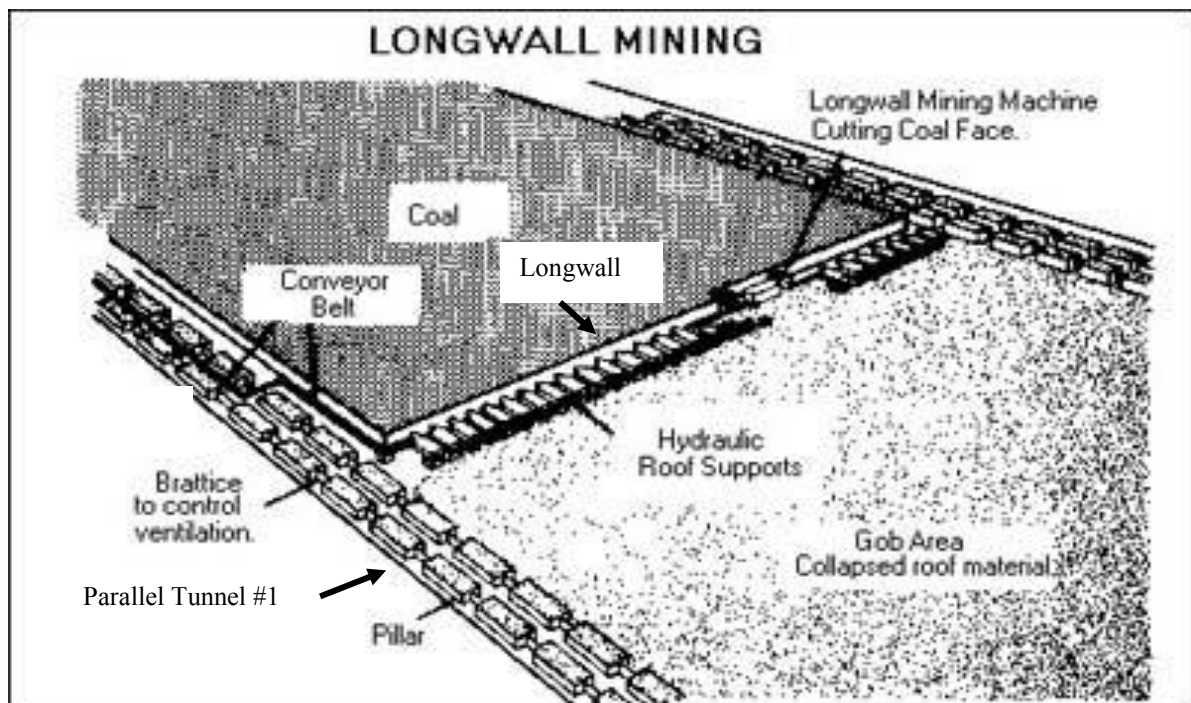
⁷⁶ Ibid.

⁷⁷ Ibid.

⁷⁸ Joint Coal Board, “Fifth Annual Report for the Financial Year, 1951 – 1952,” Appendix II, pp. 48-49.

which a conveyor and coal cutter, known as a shearer, were attached (Figure 6).⁷⁹ Prior to installing the hydraulic roof supports and putting the longwall mining machine in place, continuous miners were used to cut two parallel tunnels into the coal panel.⁸⁰ These tunnels, which were typically placed 200 meters apart, were used to place pillars to support the mine walls and roof while allowing the mining area to be properly ventilated. At the front of the coal panel, the continuous miner was used to cut another tunnel, known as the longwall, perpendicular to the two parallel roads. Finally, the continuous miner was used to cut ventilation shafts and escape tunnels as needed throughout the longwall coal mine.⁸¹

Figure 6: Diagram of a Longwall Mining Operation



Source: United Mine Workers of America website (www.umwa.org/?q=content/longwall-mining).

At that point in the development of any longwall mine, the hydraulic roof supports were put in place and the longwall mining machine, consisting of a shearer and conveyor system, was moved against the longwall. The shearer was used to extract the coal and place it on the

⁷⁹ Australian Academy of Technological Sciences and Engineering, "Technology in Australia 1788-1988," p. 760.

⁸⁰ Productivity Commission, 1998, "The Australian Black Coal Industry" Inquiry Report, AusInfo, Canberra, vol. 2, Appendix B, p. B8.

⁸¹ Ibid.

conveyor belt in one continuous operation.⁸² After the coal was removed from a particular area of the mine, the hydraulic assemblies, which are self-advancing, were moved forward into the coal panel, allowing the process of coal cutting and removal to occur on an almost continuous basis.⁸³ The roof area directly behind the mined-out area was then allowed to collapse as the longwall miner proceeds into the coal panel.⁸⁴

Once the coal was cut from the panel, it was loaded onto a conveyor, which either carried the coal directly to the surface or to a central storage area for later transfer to the surface by rubber-tired loader or second conveyor. The use of a flexible conveyor to remove the cut coal away from the coal face while moving the shearer and roof assemblies forward allowed the process to be very close to continuous. The only instances where the system needed to be shut down were (a) for maintenance, either routine or forced, and (b) if the position of the shearer needed to be reversed.⁸⁵

The longwall mining system was first used in the UK in 1963.⁸⁶ The Joint Coal Board attempted to apply the UK system in NSW between 1967 and 1970 but operating problems emerged as the UK design was not suited for NSW mining conditions. By 1972, through trial and error, the JCB developed a modified design that worked for NSW conditions.⁸⁷ In 1978, the longwall mining system accounted for only 4.3 percent of NSW underground production (1.63 mt) but by the end of the rapid growth period, its share of underground coal produced in NSW had increased to 32 percent (16.6 mt longwall versus 51.8 mt total underground production).⁸⁸ As of 1986, Queensland was just starting to apply the longwall mining system and production data were not available for the years 1978 through 1985 for Queensland. Toward the end of the rapid growth period (1980-1986), longwall mining methods started to displace bord and pillar mining methods in underground mines throughout Australia. The shift to the longwall mining system and other improvements in underground mining technology

⁸² Ibid.

⁸³ Ibid.

⁸⁴ The roof material, known in Australia as “goaf,” contains coal and needs to be properly ventilated and then sealed underground to avoid risk of dust explosions and spontaneous combustion.

⁸⁵ Ibid.

⁸⁶ Ibid.

⁸⁷ Joint Coal Board, “Twenty-Sixth Annual Report for the Financial Year, 1972-73,” pp. 48-49. The specific adjustments appear to the hydraulic roof supports and in particular the hydraulic chocks that are designed to hold up the weight of the roof.

⁸⁸ Joint Coal Board, “Black Coal In Australia, 1986-87,” p.22.

allowed worker productivity in NSW underground mines to increase from 5.76 tonnes per OMS in 1960 to 14.37 tonnes per OMS in 1986, a productivity gain of 5.8 percent per year.⁸⁹

2.2.2 Shift to Open-Cut Mining

During the rapid growth phase, advanced equipment and technology were also used to open new open-cut mines in Queensland as well as in NSW. But here the advance was one of scale and efficiency for the new equipment. Table 1 shows the massive increase in handling capacities of the overburden removal and coal extraction equipment used in Australia's open-cut mines.

Table 1: Handling Capacities of Major Pieces of Equipment Used in Australian Open-Cut Mines for Overburden Removal and Coal Extraction.

Type of Equipment	Typical Capacities in Cubic Meters	
	1950	2001
Draglines	2	46 – 60
Shovels	2	14 - 46
Heavy Excavators/Bulldozers	1.5 - 2	10.0

Source: Australian Academy of Technological Sciences and Engineering, "Technology in Australia 1788-1988 (updated 21 Nov 2001)" p. 763.

At the start of the rapid growth phase, open-cut mines accounted for only 3 percent of NSW raw coal production and 2 percent of total Australian black coal production. By the close of this period, open-cut mines accounted for 40 percent of NSW raw coal production and 67 percent of all Australia black coal production.⁹⁰ In the case of Queensland, open-cut mines accounted for 67 percent of its 1970 raw coal production and more than 93 percent of its 1986 raw coal production.⁹¹ On an OMS (all employees) basis, worker productivity in Australia's open-cut mines climbed from 14.64 tonnes per OMS (raw coal basis) in 1960 to 34.10 tonnes per OMS (raw coal) in 1986, an improvement in labor productivity of 5.4 percent per year.⁹²

⁸⁹ Joint Coal Board, "Fifteenth Annual Report for the Financial Year, 1961 – 1962," Table II, p. 20 and "Black Coal In Australia, 1986-87," Table 83, p. 78.

⁹⁰ Joint Coal Board, "Fifteenth Annual Report of the Joint Coal Board for the Financial Year 1960-1961," Table 2, p. 150 and "Black Coal in Australia 1985-86," Table 18, p. 22.

⁹¹ Joint Coal Board, "Black Coal in Australia 1985-86," Table 11, p. 22.

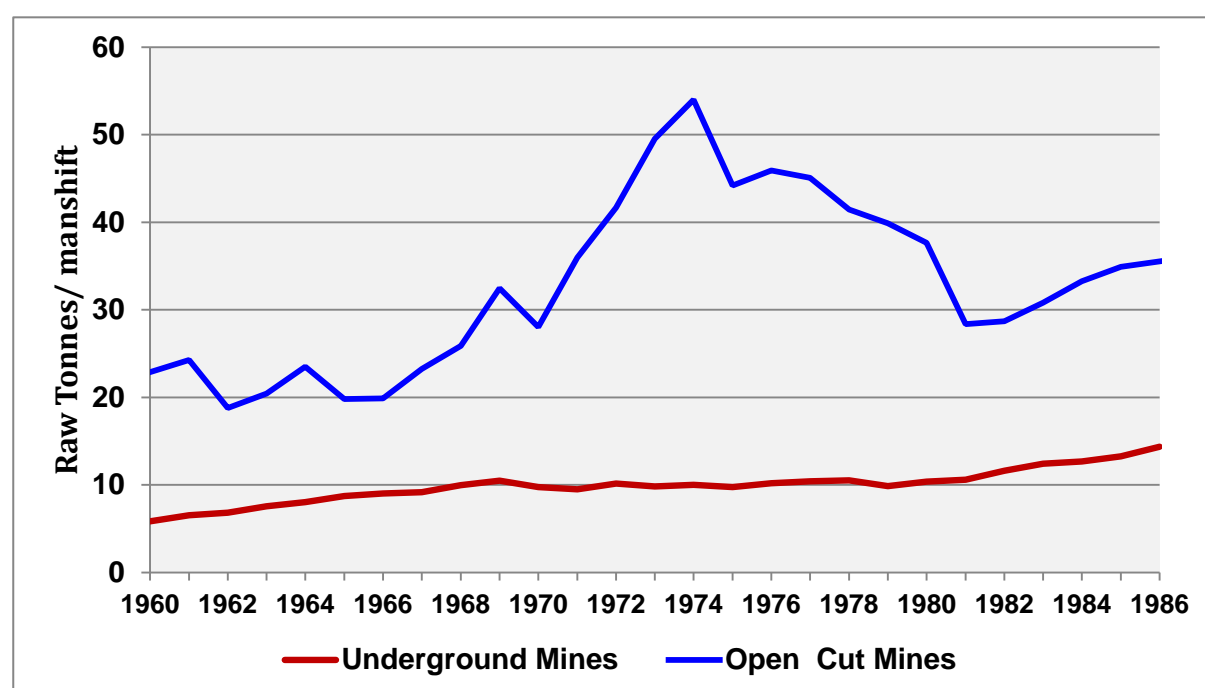
⁹² Joint Coal Board, "Fifteenth Annual Report of the Joint Coal Board for the Financial Year 1960-1961," Table 2, p. 150 and "Black Coal in Australia 1986-1987," Table 80, p. 75.

Figure 7, which shows labor productivity gains over the rapid growth period in tonnes per man shift for both underground and open-cut mines, illustrates the productivity advantages enjoyed by most open-cut mines. It is therefore not surprising that Australia's black coal industry favored the development of open-cut mines from the 1950s onward.

2.2.3 The Labor Situation Revisited

During the 1960s, lost coal production due to "industrial strife" or work stoppages was minimal. In all years except one, the lost production due to industrial strife was less than 3 percent of possible production.⁹³ However, from 1969 on, lost production due to labor disputes once again became a significant problem.

Figure 7: Raw Coal Output per Man shift (in tonnes) for All Australian Black Coal Mines, 1960-1986



Source: Joint Coal Board "Black Coal in Australia, 1986-87," Table 80, p. 75.

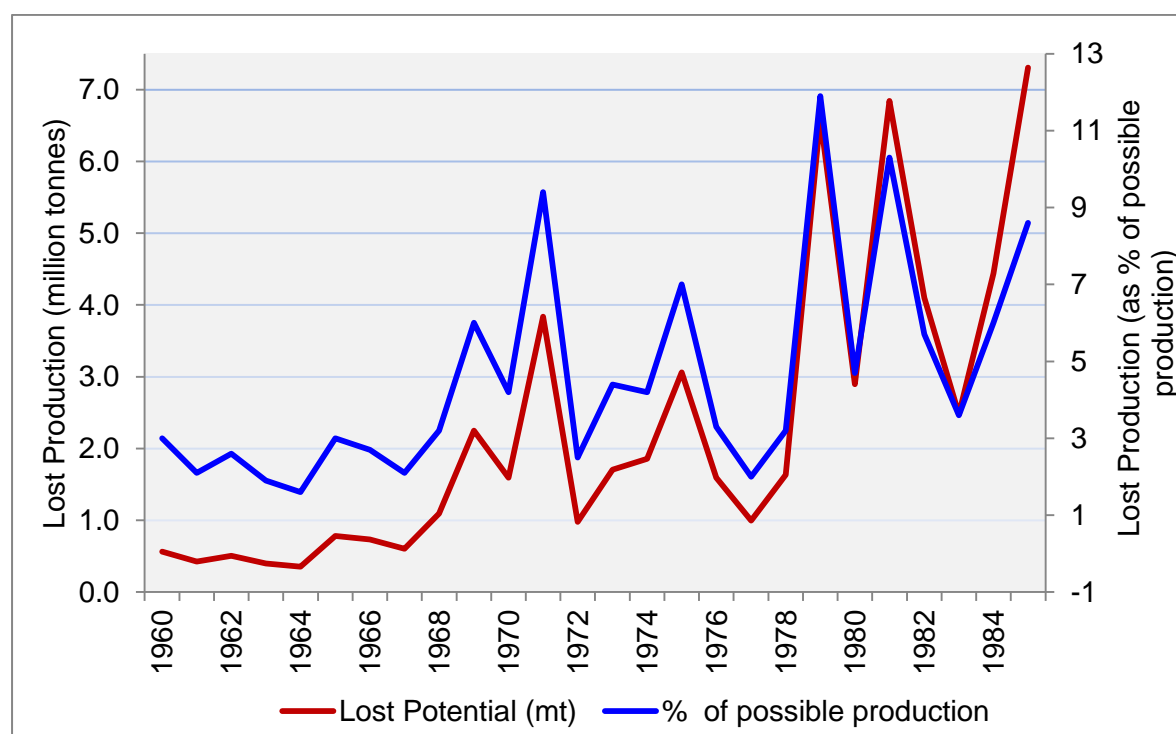
Although coal producers were able to prevent labor disputes from causing serious disruptions in production, the losses were nonetheless significant. During five of the 16 years that make up the rapid growth period (1971, 1975, 1979, 1981, and 1985) lost production due to industrial

⁹³ Joint Coal Board, "Black Coal in Australia, 1986-87," Table 95, p. 91.

strife ranged between 7 percent and 12 percent of possible production.⁹⁴ In 1979 and 1981, lost production due to industrial strife reached 12 percent and 10 percent respectively, bringing back painful memories of the years immediately after WWII when losses reached as high as 18 percent in 1949⁹⁵ (Figure 8).

The reasons for the strikes were largely over wages. It soon became apparent to miners that coal companies were not only earning banner profits due to the strong growth in their export markets but that inflation, which was running in double digits during most of the 1970s, was taking a serious bite out of their rising nominal wages.

Figure 8: Lost Production (in million tonnes and percent of possible production) due to Industrial Strife, 1960-1986



Source: Joint Coal Board, "Black Coal in Australia, 1986-87," Table 95, p.91.

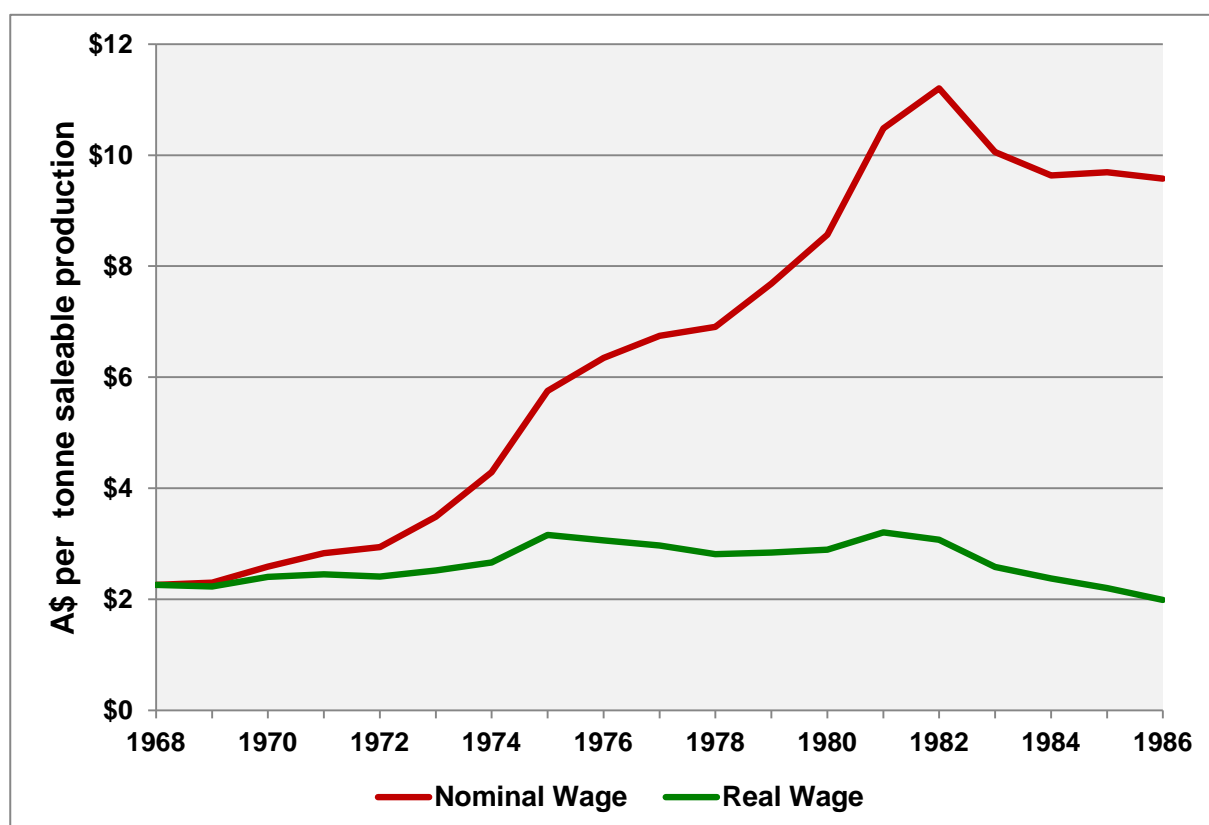
Figure 9 shows the impact of inflation on the real wage of the average NSW coal mine employee over the period 1967-1986. Although nominal wages increased smartly over most of the rapid growth period, the real wage rate for the average NSW coal mine employee increased

⁹⁴ Ibid.

⁹⁵ Ibid.

by 40 percent between 1969 and 1975 only to decrease by 35 percent over the remainder of the rapid growth period. As a result of this setback in earning power, it is hardly any wonder that miners returned to their strike-prone ways of the 1940s.

Figure 9: Nominal and Real Wages per Tonne of Saleable Coal Produced in A\$, 1968-1986



Source: ABARE, “Australian commodity statistics 2009,” Table 9, p.9 for CPI data and Joint Coal Board, “Black Coal in Australia, 1986-87,” Table 95, p.91 for nominal wage data.

2.2.4 Exports

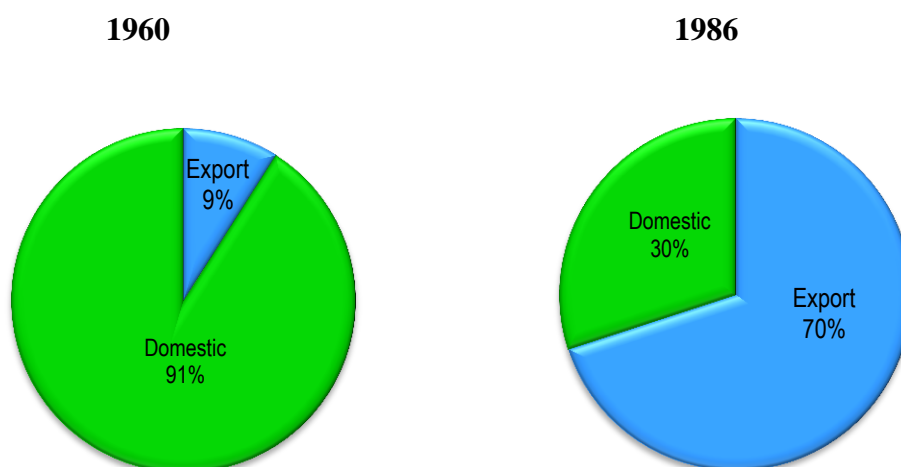
Production growth during the industry’s rapid growth phase was largely export driven with the previously dominant domestic market declining from 91 percent of total black coal sales in 1960 to 30 percent of total saleable production by 1986 (Figure 10). Between 1960 and 1986, Australia’s black coal exports increased from 1.9 mt to 95.7 mt as demand for steam and coking coal in Asia grew at an impressive 28 percent annual growth rate while domestic consumption grew at a much slower rate of 3 percent per year.⁹⁶

⁹⁶ Ibid, Table 100, p. 97.

In addition to rapid growth in production and exports, the rapid growth phase was also characterized by a very important diversification of export markets, sources of supply, and coal products. Export demand for Australia's black coal was initially dominated by Japan, which accounted for 90 percent of Australia's 1960 black coal exports.⁹⁷ The primary coal imported into Japan was hard and soft coking coal obtained from underground mines located in NSW.⁹⁸

Although Japan remained the largest export customer for Australia's black coal producers throughout the rapid growth phase of development, its share of Australia's black coal exports dropped from 90 percent in 1960 to 49 percent of total exports by 1986 as Korea, Taiwan, and Europe started to procure large quantities of Australian coking coal and later steam coal, providing Australian coal producers with a more diversified market for their exports.⁹⁹

Figure 10: Exports and Domestic Coal Sales, 1960 and 1986



Source: Joint Coal Board, "23rd Annual Report, 1969-70," Table 9, p. 249.

Joint Coal Board, "Black Coal in Australia, 1986-87, (January 1988)," Table 100, p.97 (export) and Table 133, p. 126 (domestic).

Australia's initial reliance on the Japanese export market over the rapid growth phase benefited the coal industry in a number of ways. The primary benefit was to create predictable and long-

⁹⁷ Joint Coal Board, "Fifteenth Annual Report of the Joint Coal Board for the Financial Year 1960-1961," p. 75.

⁹⁸ Ibid.

⁹⁹ Joint Coal Board, "Black Coal in Australia, 1986-87," Table 126, p. 117.

term revenue streams for new mining projects, which allowed mining companies to obtain long-term financing for both mining and transport infrastructure projects in NSW and Queensland.

The Commonwealth government, however, did not initially view the relationship in such symbiotic terms. Instead, it worried that Japan, because of its collective price bargaining methods, would exert market power over Australia's coal producers, resulting in coal producers accepting below-market prices for their exports and reduced royalties and tax revenues for the Commonwealth and state governments. As a result of this concern, the Australian government, in 1973, imposed price controls on all coal exports. These price controls were not removed until 1993 but were only weakly enforced after 1983.¹⁰⁰ In retrospect, the Australian government now realizes the Japanese coal buyers have since 1990 been paying a premium for the steam coal that it procures from Australia.¹⁰¹

2.2.5 Queensland Becomes Australia's Largest Black Coal Producer

Between 1960 and 1986, Australia's black coal industry also diversified the supply side of its export business with Queensland replacing NSW as Australia's largest black coal exporter in 1975.¹⁰² Queensland's expansion of its black coal production was largely the work of Utah International (Utah), an American mining company. Between 1973 and 1982, Utah accounted for more than 70 percent of Queensland's black coal exports.¹⁰³ Utah's share of Queensland's total coal exports dropped from a peak of 85 percent in 1978 to 39 percent by the end of the rapid growth phase.¹⁰⁴

¹⁰⁰ See Bowen, Bruce, and Peter Gooday, "Coal: The economics of coal export controls," ABARE Research Report 93.8, ABARE 1993.

¹⁰¹ ABARE, "Australian Commodity Statistics 2001," Tables 253 and 257, pp. 253 and 258. ABARE commodity statistics for the period 1990-2000 indicate that the FOB price paid by Japan for Australian steam coal was higher than the average FOB prices paid by European and other Asian buyers of Australian steam coal. Moreover, ABARE commodity statistics for the period 1992-2000, indicate that Japan sourced 60 percent to 70 percent of its steam coal and 45 percent to 58 percent of its coking coal from Australia. Japan's heavy dependence on Australia for its black coal supplies probably acted to neutralize most of Japan's market power over Australia's black coal producers.

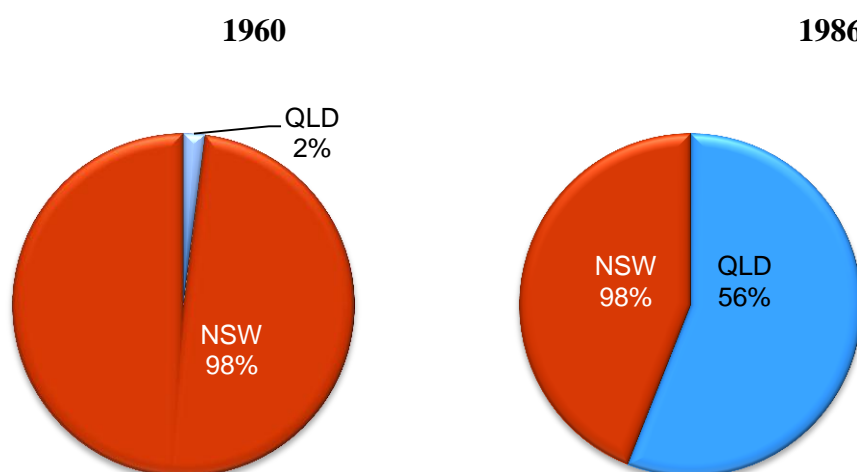
¹⁰² NSW still remained the largest producer of saleable black coal due to the large quantity of black coal used by NSW's steel-making and power-generating industries. In 1975, NSW consumed 19 mt of black coal in domestic markets while Queensland had a much smaller domestic market requirement of 5.3 mt. It wasn't until 1983 that Queensland became the largest total producer of saleable black coal.

¹⁰³ Utah International also played a major role in establishing Indonesia's coal industry on Kalimantan. For a superbly researched book on the subject of Utah International's role in the development of Queensland's black coal industry, the reader is referred to Galligan, Brian, *Utah and Queensland Coal: A Study in the Micro Political Economy of Modern Capitalism and the State*, University of Queensland Press, 1989.

¹⁰⁴ Galligan, Brian, *Utah and Queensland Coal: A Study in the Micro Political Economy of Modern Capitalism and the State*, University of Queensland Press, 1989, Table 1, p. 27.

The shift in supply-side dominance from NSW to Queensland was not due to lack of growth in NSW's exports of black coal. NSW black coal exports increased during this development phase at a growth rate of more than 21 percent per year, with export tonnage increasing from 1.9 mt in 1960 to 42.2 mt in 1986.¹⁰⁵ It was just that Queensland's export growth was so much faster. Over this same period, Queensland's black coal exports grew at 33 percent per year. Starting from a very small export tonnage of 48,000 tonnes in 1960 and representing just 2 percent of Australia's black coal exports, Queensland's black coal exports grew to 53.5 mt in 1986, which translated into a 56 percent share of total black coal exports (Figure 11).¹⁰⁶

Figure 11: Queensland and NSW Shares of Black Coal Exports, 1960 and 1986



Source: Joint Coal Board, "Black Coal in Australia, 1986-87," Table 100, p. 97.

In addition to having vast coking coal deposits that were amenable to open-cut mining, Queensland also had a better "topography"; it had multiple locations for constructing deep-sea coal ports, such as Gladstone, Hay Point, and Abbot Point. NSW's coal industry, on the other hand, was largely limited to the Port of Newcastle for exporting its coals due to draft limitations along most of its coast and mountain ranges that separate the inland Hunter Valley coalfields from the coast. Finally, Queensland's coal export terminals, especially the Abbot Point Coal Terminal, are located closer to the markets of North Asia, the largest market for Australia's black coal during the rapid growth phase. Abbot Point in particular has a round-trip

¹⁰⁵ Joint Coal Board, "Black Coal in Australia, 1986-87," Table 100, p. 97.

¹⁰⁶ Ibid.

sea vessel journey to Japan that is at least two days shorter than the round-trip journey from the Port of Newcastle to Japan.

2.2.6 Product Diversification

A third area of export diversification was in the types of coal offered to its customers. From 1960 through 1975, Australia's black coal industry shifted from almost total reliance on coking coal as its sole coal export to a combination of coking and steam coal. While there are multiple grades of coking coal, Australia, at the beginning of the rapid growth phase, was dependent on a single industry—steelmaking. The small amount of steam coal that was exported over that period was largely to Europe.

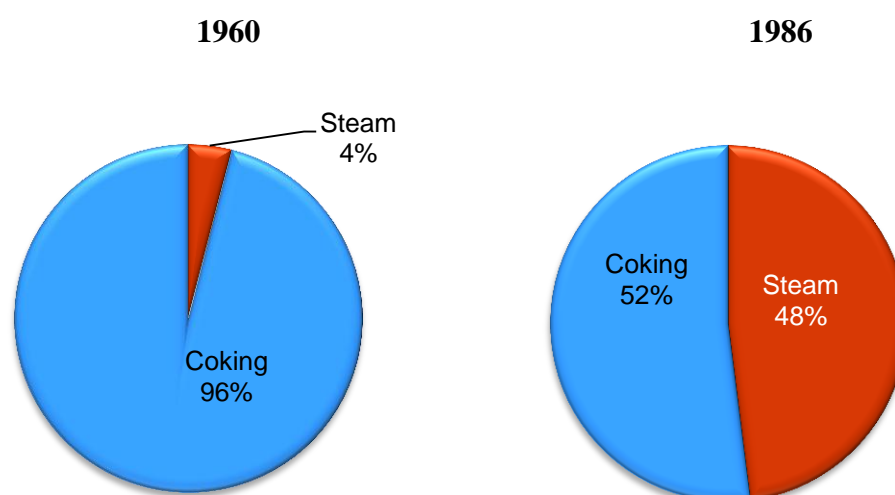
Between 1960 and 1969, steam coal exports increased from 85,000 tonnes to 877,000 tonnes, an impressive growth rate of 30 percent per year, but the quantities were still so small as to be considered negligible.¹⁰⁷ From 1976 onward, however, exports of steam coal continued to grow at 31 percent per year, resulting in steam coal exports increasing from 3.2 mt in 1976 to 45.9mt in 1986.¹⁰⁸ Coking coal's share of Australia's black coal exports was 52 percent in 1986, still a large market share but down significantly from its overwhelmingly large 1960 market share of 96 percent (Figure 12).¹⁰⁹

¹⁰⁷ Ibid.

¹⁰⁸ Ibid.

¹⁰⁹ Ibid.

Figure 12: Steam Coal and Coking Coal Shares of Total Exports, 1960 and 1986



Source: Joint Coal Board, “Black Coal in Australia, 1986-87,” January 1988, Table 100, page 97.

The shift in exports from coking coal to steam coal was largely the result of the Arab Oil Embargo of 1973, which led OPEC to increase its posted crude price from \$2.50 in early 1973 to more than \$12 per barrel by 1975. This massive oil price increase put “at risk” Asia’s power systems, which were almost totally dependent on cheap oil. The growth in steam coal exports was “encouraged” further by the Iranian Oil Crisis of 1978, which resulted in the OPEC posted price peaking at \$39.50 per barrel in 1980. As a result of these two oil price shocks, Japan, and later Taiwan and Korea, saw steam coal and uranium as the most cost-effective alternatives to petroleum products as a fuel source for power generation and over the period 1980–1995 built many new coal-fired power plants, which expanded their demands for Australian steam coal.

2.2.7 Port System Expansion

The major coal handling ports of NSW (Newcastle) and Queensland (Gladstone, Hay Point and Abbot Point) were either built or expanded during the rapid growth phase.

The Port of Newcastle, which as of 2010 was the world’s largest coal export port, has the longest history of all of Australia’s world-scale coal export ports. Its first commercial shipment of coal—50 tonnes—occurred in 1799.¹¹⁰ During the rapid growth phase, the Port of Newcastle became a significant player in the coal export markets with the commissioning of

¹¹⁰ <http://www.newportcorp.com.au/site/index.cfm?display=111710> (History, Australia’s First Port).

two coal terminals known as Carrington and Kooragang. The Carrington Coal Terminal (CCT) was commissioned in 1976 with a ship loading capacity of 16 mtpa while the Kooragang Coal Terminal (KCT) was commissioned in 1984 with an initial ship loading capacity of 25 mtpa.¹¹¹

The Port of Gladstone commissioned two coal terminals—the Barney Point Coal Terminal (BPCT) and the RG Tanna Coal Terminal (RGTCT)—during the rapid growth phase. BPCT was commissioned in 1967 as a dedicated terminal for the export of Moura coal produced by the Thiess Peabody Mitsui (TPM) Coal Pty. Ltd.¹¹² The Port of Gladstone commenced the construction of BPCT in the mid-1960s with first coal (1,600t) shipped from BPCT in 1967.¹¹³

Gladstone Port Authority (GPA), which is now known as the Gladstone Ports Corporation (GPC), purchased BPCT in 1968. RGTCT, which was originally named the Clinton Coal Facility, was approved for construction by the GPA in 1976 after BHP Co. Ltd. confirmed that it had secured long-term contracts for the sale of coking coal to Japanese steel mills.¹¹⁴ Stage one of the facility was completed in 1980 at a cost of A\$45 million. During its first full year of operation, RGTCT exported 4.3 Mt of coal.¹¹⁵

The Port of Hay Point, which is located in Queensland, north of Gladstone, is Australia's second largest coal export port. It is owned by the North Queensland Bulk Ports Corporation (NQBP), which was formed in July 2009 through the merger of the Ports Corporation of Queensland, with the Port of Mackay. Hay Point consists of two coal terminals, Hay Point and Dalrymple Bay. The Hay Point Coal Terminal (HPCT) was originally constructed and owned by Utah International.¹¹⁶ It has been operating since 1971. It is currently owned and operated by the BHP Billiton Mitsubishi Alliance (BMA) and serves as a dedicated terminal for coal exports of BMA.¹¹⁷ The Dalrymple Bay Coal Terminal (DBCT) was commissioned in 1983 as a common user facility with a ship loading capacity of 15 mtpa.¹¹⁸

¹¹¹ <http://www.newportcorp.com.au/site/index.cfm?display=111710> (Port of Newcastle; Facilities).

¹¹² <http://www.gpcl.com.au/history.html> (About GPC; History of GPC).

¹¹³ Ibid.

¹¹⁴ Ibid. In 1994, the Clinton Coal Facility was renamed the RG Tanna Coal Terminal (RGTCT), “in recognition of the efforts of Reg Tanna,” general manager of the Port of Gladstone during the early 1990s.

¹¹⁵ Ibid.

¹¹⁶ Galligan, Brian, *Utah and Queensland Coal: A Study in the Micro Political Economy of Modern Capitalism and the State*, University of Queensland Press, 1989, p. 104.

¹¹⁷ <http://www.nqbp.com.au/index.cfm?contentID=4> (NQBP Ports; Hay Point).

¹¹⁸ Ibid (NQBP Ports, Hay Point).

The Port of Abbot Point, which is located in the far north of Queensland, is also owned and operated by the North Queensland Ports Corporation. It contains a coal terminal, known as Abbot Point Coal Terminal (APCT), which was commissioned in the early 1980s.¹¹⁹ It is owned by the Abbot Point Bulk Coal Pty. Ltd., a subsidiary of Xstrata Coal Queensland Pty. Ltd. Information on APCT's actual commissioning date and initial ship loading capacity was not available, either online or from other sources. Other ports located in Queensland and NSW with coal handling capability are Brisbane in Queensland and Port Kembla in NSW. Information on their commissioning dates and initial ship loading capacities were also not available from online sources such as the port authority's website.

2.2.8 Rail Transport Systems

During the rapid growth phase, the states of Queensland and NSW constructed extensive rail networks to haul coal from their inland coal mines to coastal export ports. They also constructed railway spurs that delivered coal to specific power plants throughout each state. For the entire rapid growth phase, the railway systems of NSW and Queensland were owned and operated by the governments of the states within which they operated.¹²⁰

The starting point for the development of Queensland's rail system was 1884, when the Griffith government secured a 10 million pound loan for railroad expansion. These early rail lines were primarily to haul passengers and agricultural products to market, which is not surprising since Queensland's coal production amounted to less than 100,000 tonnes in 1881 and remained below 1 mtpa until 1913.¹²¹

It was not until the late 1960s that the government of Queensland made a serious effort to develop a rail network for hauling coal from the Bowen Basin to the ports of Gladstone and Hay Point. The first major coal haul line was the Moura Short Line, which was completed in

¹¹⁹ <http://www.dip.qld.gov.au/resources/major-projects/presentations/mpc10/brad-fish.pdf>.

¹²⁰ During the period 1850-1860, the state colonial governments were willing to allow the private sector to build, own, and operate rail systems. However, due to financial constraints, these private rail systems were within a short period of time taken over by government. For example, a private company, which attempted to build a railway in NSW in 1854, went bankrupt in 1855 and had to be taken over by the government before completion. South Australia's railways were government owned from the beginning, including a horse-drawn line that opened in 1854 and a steam-powered line that opened in 1856. In Victoria, private railways became insolvent soon after starting operations and were soon thereafter taken over by the colony government.

¹²¹ Official Australia Yearbook, 1916, "Non-Metallic Minerals: Coal," p. 426.

1968 with funding provided by Theiss Brothers and other mining companies.¹²² It was built and operated by government-owned Queensland Railways (QR), as part of its network.¹²³ Between 1960 and 1984, QR constructed additional coal haul lines between coal mines located at (a) Moura, (b) Koorilgah, (c) Laleham, (d) Curragh, (e) Gregory, and (f) Gordonstone to the Port of Gladstone. Spur lines and other expansions were constructed in the Blackwater area, as well as on the Goonyella system from the Port of Hay Point to Goonyella and Blair Athol. Many of these lines were funded by Utah International, Theiss Brothers, and other mining companies that were developing mines in the Bowen Basin.¹²⁴

Other mineral haul lines were built to Cobarra near Townsville and Greenvale for nickel ore and Phosphate Hill in the Cloncurry district. In the mid-1980s the main coal haul rail lines in central Queensland were electrified and more than 1,600 kilometers of railway lines were upgraded to allow increased amounts of coal being moved to export ports in central Queensland.¹²⁵

2.2.9 Domestic Consumption

During Australia's rapid growth phase, domestic markets for black coal became increasingly dominated by the power industry with steel and iron production and other industries combined providing a "second" significant domestic market. The power industry was always a large black coal user. The change was one of consolidation with the disappearance of three previously significant users of black coal—railway locomotives, town gas producers, and sea vessels. Figure 13 shows the evolution of the domestic black coal market for all of Australia between 1960 and 1986.

The loss of the town gas business started in the 1950s with the replacement of town gas with low-cost refinery gases.¹²⁶ However, the ultimate demise of the town gas business resulted from the discovery, in 1967, of large oil and gas fields in the Gippsland Basin, which is located offshore from the state of Victoria. A gas pipeline system was developed, and natural gas supplies from the offshore Gippsland oil and gas fields and the onshore gas fields of the Cooper Basin were brought to most major cities. The development of the retail gas industry in

¹²² Galligan, Brian, *Utah and Queensland Coal: A study in the Micro Political Economy of Modern Capitalism and the State*, University of Queensland Press, 1989, pp. 202-203.

¹²³ Ibid.

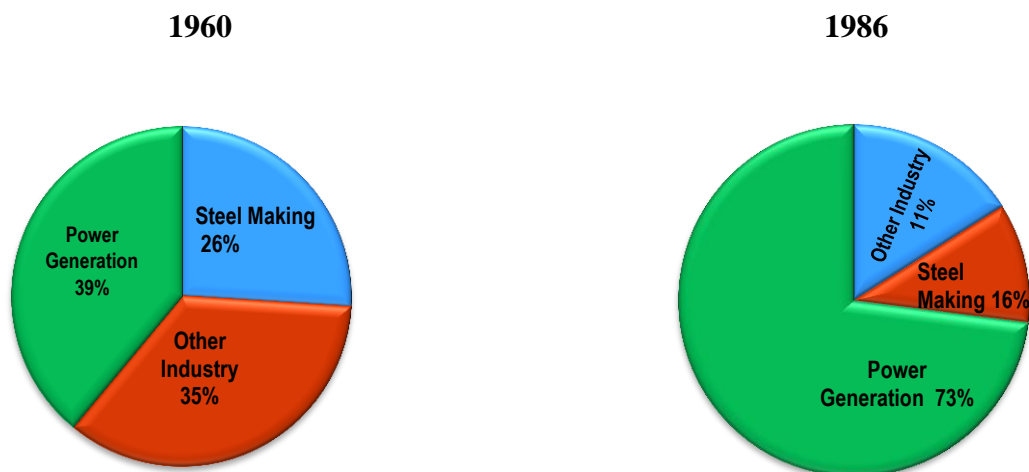
¹²⁴ Ibid, pp. 43-76.

¹²⁵ www.qld.gov.au/assetssale/businesses/qv-national/docs/railing-queenslands-coal-section-2.pdf, section 2: The Tracks, p. 10.

¹²⁶ <http://www.austehc.unimelb.edu.au/tia/820.html> (Manufactured Gas; The New Technology).

NSW, Queensland, Victoria, and South Australia led to the shutdown of most town gas plants by 1975.

Figure 13: Shares of Domestic Consumption by Industry, 1960 and 1986

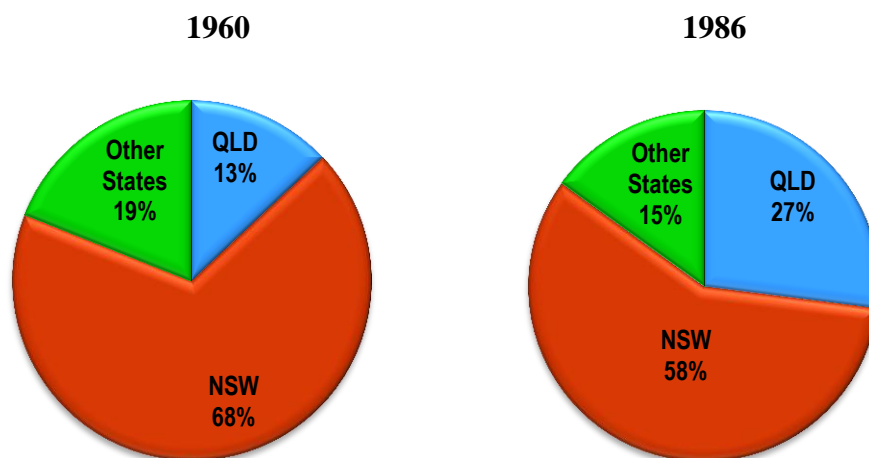


Sources: Australian Official Year Book, #49,1962, p. 1090.

Joint Coal Board, "Black Coal in Australia, 1986-1987," Table 133, p.126.

General industry, commercial, and domestic consumers also made a significant shift out of coal and into natural gas and petroleum products over this time period. This shift was made for reasons of cost as well as convenience. Ironically, the domestic market experienced a growth slowdown and became more concentrated over the industry's rapid growth phase, while the export side of the business experienced exceptional growth and diversification. The domestic market diversified somewhat from one that was dominated by NSW to one that had a slightly better balance between states (Figure 14).

Figure 14: Queensland Doubled Its Share of Black Coal Consumption between 1960 and 1986



Sources: Joint Coal Board, “19th Annual Report, 1965-1966,” Table 36, p. 71.

Joint Coal Board, “Black Coal in Australia, 1986-1987,” Table 132, p. 125.

2.2.10 Evolution of Mining Regulatory Frameworks

During the rapid growth period, each state maintained its own laws and regulations related to the awarding of coal exploration and mining licenses, known in Australia as tenements.¹²⁷ In general, these mining laws were attuned to the production methods and technologies in use prior to WWII, a time when coal mining was a small-scale, labor-intensive industry. For example, Queensland’s coal mining companies, during the 1960s, were regulated under a mining law that was passed into law in 1925.¹²⁸

During the 1960s and 1970s, especially in the state of Queensland, large mines were developed in outlying areas lacking rail and basic community infrastructure and amenities. Developing these new mining areas required the private companies to make massive investments in new rail and port facilities and to support the establishment of new communities and towns for housing the miners and their families. Despite being subjected to numerous amendments, the existing laws and supporting regulations did not provide a

¹²⁷ Limited information is available from government sources concerning the specific regulations and laws that were in force during the rapid growth phase.

¹²⁸ Queensland State Government, “Coal Mining Act 1925.”

sufficient framework for developing these large-scale, capital-intensive mechanized mining operations.¹²⁹

To get around the limitations of archaic mining laws, mining companies were forced to engage in negotiations with the minister responsible for mining in each state in order to obtain licenses over large areas. The terms and conditions of the agreements reached between each company and the relevant minister were then embodied in an act of that state's Parliament.¹³⁰ In the case of Queensland, an act of Parliament, known as the Central Queensland Coal Associates (CQCA) Agreement Act, No. 58 of 1968, assented to on December 24, 1968, was passed into law and appears to have provided most of the regulatory support for open-cut coal projects implemented during the 1970s and 1980s.¹³¹

This cumbersome and uncertain method of acquiring a new mining license required numerous amendments to the special law(s) passed to support the development of specific projects. The process of making these amendments and passing special laws was very expensive for individual companies to pursue and politically risky for both companies and governments to implement. In 1972, the Queensland government passed into law the Queensland Mining Act of 1968 to 1971 to resolve the issues related to ad hoc licensing agreements. NSW followed with the New South Wales Act 1973, which become effective as a law in 1974. South Australia also passed a new mining law in 1972.¹³²

But even these so-called "modern mining acts" were found to be wanting and the ad hoc approach to issuing a mining license, i.e., direct negotiations with the minister-in-charge followed by the passing into law either a supporting act of Parliament or an amendment to an existing act, continued to be used by the governments of Queensland and NSW as part of the

¹²⁹ Brian Galligan's *Utah and Queensland Coal: A Study in the Micro Political Economy of Modern Capitalism and the State*, University of Queensland Press, 1989, pp. 44-76.

¹³⁰ Official Yearbook of Australia, number 61, 1975-76, page 932. This ad hoc method of awarding mining licenses was very similar to the approach followed by Indonesia between 1970 and 2000. In Indonesia, government-to-business (G-T-B) agreements, known as coal contracts of work, effectively launched Indonesia's steam coal industry, which to this day is dominated by companies operating under G-T-B CCOWs (Bart Lucarelli, "The History and Future of Indonesia's Coal Industry: Impact of Politics and Regulatory Framework on Industry Structure and Performance," PESD Working Paper #93, July 2010, pp. 17-35). This method of awarding mining licenses has now been officially replaced by a system of mining licenses similar to the system that is now being followed in Australia.

¹³¹ Brian Galligan, *Utah and Queensland Coal: A Study in the Micro Political Economy of Modern Capitalism and the State*, University of Queensland Press, 1989, pp. 45, 60-66.

¹³² Ibid.

process of awarding licenses for large mining projects.¹³³ These government-to-business (G-T-B) Agreements, such as the CQCA Agreement Act of 1968, had the force of law. This act, which remains in effect today, led to the development of Queensland's vast coking coal resources. During the mid-1970s, Utah International was producing more than 80 percent of Queensland coal exports under the protection of the CQCA Agreement Act.¹³⁴

The role of the JCB also changed. When it was established in 1946, the Commonwealth and NSW governments empowered the JCB with broad and sweeping powers. In particular, they set the powers and functions of the JCB to take any actions necessary in order to ensure that

- (a) "Coal is produced in the State (NSW) in such quantities and with such regularity as will meet requirements throughout Australia and in trade with other countries;
- (b) The coal resources of the State are conserved, developed, worked and used to the best advantage in the public interest; and
- (c) Coal produced in the State is distributed and used in such manner, quantities, classes and grades and at such prices as are calculated best to serve the public interest and secure the economical use of coal and the maintenance of essential services and industrial activities."

The JCB also was mandated to promote the welfare of workers engaged in the coal industry in the state. Of its four objectives, the JCB clearly viewed promoting the welfare of workers as "subsidiary" to the other three objectives.

By 1970, the JCB was so successful in achieving its four objectives that its role shifted from organizing the mechanization of mines, setting prices, and controlling production to a role that focused on the publication of a very detailed statistics report titled "Black Coal in Australia" and overseeing safety programs. In 1983, the Commonwealth and NSW governments conducted a review of the powers, structures, and membership of the JCB. The two governments decided to keep the JCB's existing structure and powers but changed the members of the JCB board to include union and mining company representatives. They also required the JCB to appoint an independent chairman of the board. Although it was allowed to

¹³³ Official Year of Australia, number 73, 1990, p. 469.

¹³⁴ Indonesia copied the CQCA approach during the 1980s. Unsurprisingly, Utah International, one of the parties to the CQCA, was a leading developer of mining areas on Kalimantan during the early 1980s.

continue its more limited operations, the continued role of the JCB was now starting to be questioned within government and industry.

2.2.11 Export Contract Arrangements

Japan was the dominant export customer during the entire rapid growth period, though Korea and Taiwan became significant customers toward the end of this period. Many Japanese customers held equity stakes in their sources of coal supply through a Japanese trading house. As buyers, the Japanese felt that their representation within the coal supply company would allow cost-plus pricing arrangements to be effectively monitored for fairness.¹³⁵ The objective of Australian coal suppliers was to achieve revenue certainty, which would support bank and equity financing for their green-field mining projects. In the case of the Japanese buyers, the top concern was security of coal supply. Price appeared to be of secondary concern. In this context, the interests of the buyer (Japanese steel mill or power utility) and seller (Australian coal producer) appear to have been aligned at the start of the cost-plus negotiations.

Japanese customers and Australian coal suppliers opted for long-term, cost-plus coal supply contracts with terms ranging from 10 to 15 years. The cost-plus agreements provided for a starting coal price and pre-set escalation factors that allowed price adjustments over the term of each contract.¹³⁶ These contracts stipulated that the escalators and cost-plus arrangements were to be reviewed after a fixed time period.

However, this arrangement became much more difficult for buyers to police than originally expected. More importantly, the true market price, as measured by spot and later term contract transactions, diverged significantly, year to year, from the prices resulting under the previously agreed cost-plus mechanisms.¹³⁷ This divergence from market became especially problematic during the 1970s, when the price of oil and other commodities increased dramatically as a result of the twin oil price shocks of 1973 and 1978.¹³⁸

¹³⁵ The best examples from Queensland were the Theiss-Mitsui and the Utah-Mitsubishi partnerships from the 1960s, which led to the development of the massive coking coal deposits of the Bowen Basin. Today, the Utah-Mitsubishi partnership has morphed into the BHP-Billiton/Mitsubishi Alliance or BMA.

¹³⁶ Productivity Commission, 1998, "The Australian Black Coal Industry" Inquiry Report, AusInfo, Canberra, vol. 2, Appendix D, p. 12.

¹³⁷ Productivity Commission, 1998, "The Australian Black Coal Industry" Inquiry Report, AusInfo, Canberra, vol. 2, Appendix D, p. 12.

¹³⁸ Ibid.

Over time, pricing provisions of term contracts were revised to allow annual negotiations of the price, quantity, and quality for any coal sales in each year.¹³⁹ Certain contracts such as the Utah-Mitsubishi contracts with Japanese steel mills contained provisions that allowed significant price adjustments in the event that cost-plus prices diverged from future spot and term prices.¹⁴⁰ Other contracts had their price provisions revised to reflect market conditions either at the strong behest of the coal supplier or as a requirement of the Commonwealth government during the 1970s. Once the long-term contracts expired, the parties to these contracts had developed a sufficiently strong working relationship that they simply relied on annual price and quantity negotiations rather than long-term contracts to determine price and quantity of coal to be delivered in any years.¹⁴¹

2.2.12 Export Prices for Australian Black Coal

Between 1960 and 1973, the average A\$ FOB price per tonne that Australian coal producers received for their black coal exports varied between \$8.00 and \$12.50 per tonne. This period is now viewed with a fair degree of nostalgia by coal buyers as a time when energy prices in general and Australian black coal price in particular were stable and at very low levels. The low energy price environment was supported by a stable US\$:A\$ exchange rate, which was the result of the Bretton Woods Accord that the United States and other major Western economies signed in 1944.

The stable and low energy price environment started to unravel during October 1971, when the United States unilaterally terminated its participation in the Bretton Woods Accord. As a result of its unilateral action, the US\$ depreciated significantly against the A\$ between 1972 and 1974. Since Australia's black coal exports were priced in US\$, this market reaction would normally have resulted in Australia's black coal producers reducing their output and/or exerting pressure on miners to accept very small adjustments in their annual wages. However, in October 1973, Australia's coal producers were rescued from that possible predicament by OPEC, which imposed an embargo on oil exports to the United States and a number of other Western countries as punishment for their bias toward Israel during the 1973

¹³⁹ Ibid.

¹⁴⁰ Brian Galligan *Utah and Queensland Coal: A Study in the Micro Political Economy of Modern Capitalism and the State*, University of Queensland Press, 1989, p. 152

¹⁴¹ Productivity Commission, 1998, "The Australian Black Coal Industry" Inquiry Report, AusInfo, Canberra, vol. 2, Appendix D, p. 12

Yom Kippur War.¹⁴² Along with the oil embargo, Saudi Arabia and other Arab state members increased OPEC's posted oil price in October 1973 from \$3.00 per barrel to 5.11 per barrel.¹⁴³

By 1975, the price of oil rose as high as \$12 per barrel after which it traded between \$12 and \$15 per barrel from 1975 through 1978. Then, in 1979, the shah of Iran fell, leading to the Iranian Oil Crisis, which resulted in the price of oil increasing from \$15.85 per barrel (April 5, 1979) to \$39.50 per barrel in early 1980. From that point on, an oil glut emerged causing nominal oil prices to slide to around \$10 per barrel by 1986.¹⁴⁴

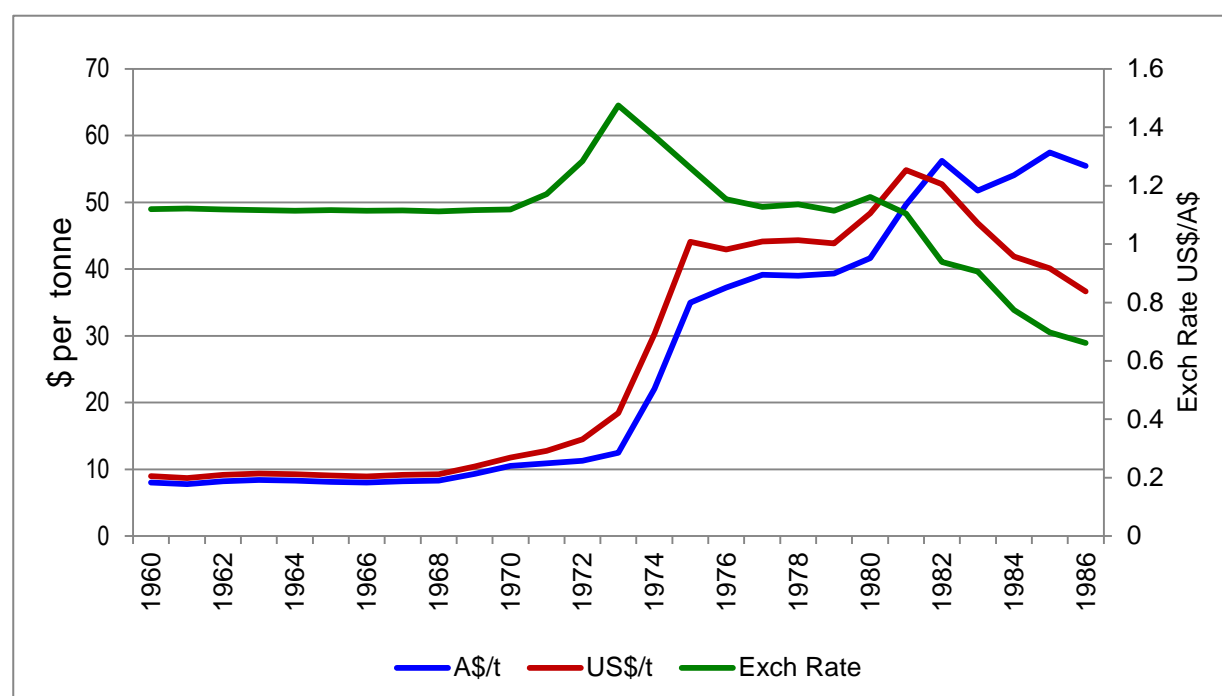
The impact of the oil price increases and decreases during the 1970s and 1980s was a significant factor in driving the expansion of Australia's black coal exports. The increase in the FOB A\$ price for Australian black coal provided Australian coal producers with substantial windfall profits through 1980. Between 1980 and 1986, the nominal US\$ price for Australian black coal decreased from \$54.85 to \$36.65 per tonne, a 33 percent decline. However, the impact on the A\$ price of this large drop in the US\$ price was more than offset by the 40 percent depreciation in the A\$ against the US\$ over the same time period (Figure 15).

¹⁴² Jay Hawkes, "35 Years After the Arab Oil", 06 October 2008 ([www.ensec.org/index?view=article&catid](http://www.ensec.org/index?view=article&catid=http://www.ensec.org/index.php?view=article&catid)
<http://www.ensec.org/index.php?view=article&catid>) .

¹⁴³ Daniel Yergin, "The Prize: The Epic Quest for Oil, Money and Power (New York: Simon and Shuster, 2008), p.589.

¹⁴⁴ James L. Williams "Oil Price History And Analysis"(2007: WTRG Economics) available from <http://www.wtrg.com/prices.htm>)

Figure 15: Changes in the Average Nominal FOB Price for Australian Black Coal in A\$ and US\$ per Tonne, 1960-1986



Source: Joint Coal Board “Black Coal in Australia,” Table 108, p. 104.

2.2.13 Establishment of the Australasian Joint Ore Reserves Committee (JORC)

One under-reported “regulatory” event during the rapid growth phase, which has become of great value to the mining industry, was the establishment of the Australasian Joint Ore Reserves Committee (JORC).¹⁴⁵ The Australian Mining Council (AMC) created JORC in 1971 with the mandate to develop clear and consistent rules and guidelines for mining companies to apply before making any public declarations of their mineral resources and reserves.¹⁴⁶

JORC issued a number of reports between 1972 and 1989, which recommended improved procedures for publicly reporting and classifying coal deposits. These reports formed the basis for the first JORC Code, which was issued in 1989.¹⁴⁷ It was immediately adopted by the Australian Stock Exchange (ASX) and imposed by the ASX as a mandatory requirement for all publicly listed coal mining companies to use when reporting their ore reserves. The JORC

¹⁴⁵ Joint Ore Reserves Committee, “JORC — Its History, its Sponsors, and Current Committee,” September 27, 2009, p. 1.

¹⁴⁶ Ibid. The AMC created JORC to address “unacceptable reporting associated with the Poseidon nickel boom and bust in Western Australia,” an event that occurred during the late 1960s and destroyed investor confidence in the declarations of reserves by many publicly traded mining companies.

¹⁴⁷ Ibid.

Code is now in its fourth version and is widely accepted in Australia and throughout Asia as the highest standard for reporting coal resources and reserves.

2.3 The Competitive Phase (1987-2003)

The greatest industry concern throughout the 1990s and the competitive phase was whether Australia could continue to compete in Asian markets against competitors from Indonesia and China. The competitive phase lasted for 16 years, with many industry analysts believing, as late as 2003, that it would continue for at least another decade.

2.3.1 Declining Real FOB Prices and International Competitiveness

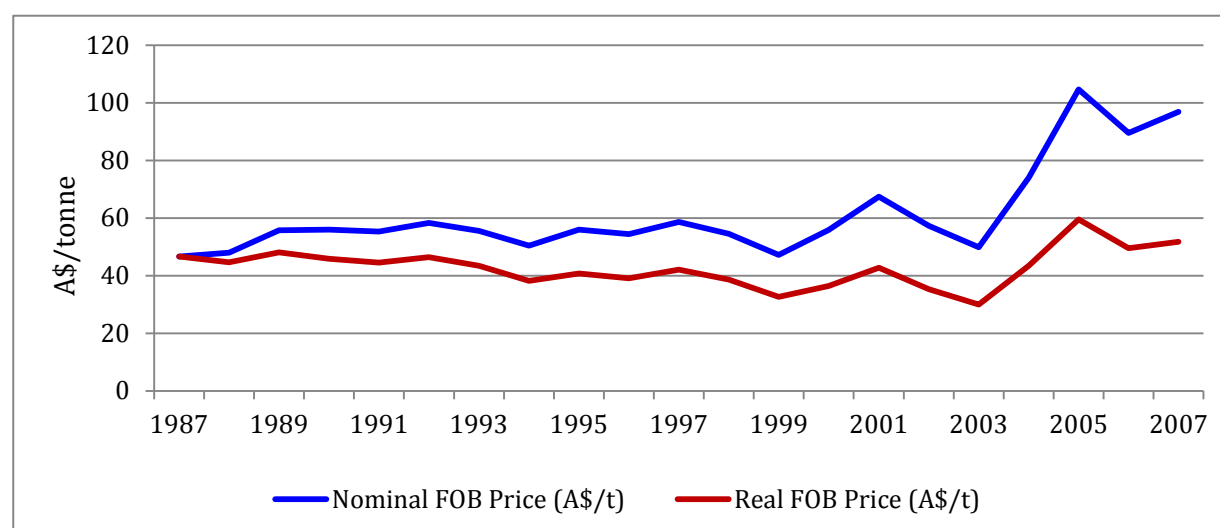
Between 1987 and 1996, Australian black coal producers experienced a 16 percent decline in the average real price for their black coal exports. (Figure 16) Then, in 1997, Australia's black coal producers were confronted by the Asian Financial Crisis, which continued to adversely impact Asian demand for black coal through 2003.¹⁴⁸

In response to these threats to Australia's black coal industry, Australia's Commonwealth government commissioned the Productivity Commission in 1997 to examine the competitive position of Australia's black coal industry and make recommendations for improving its international competitiveness.¹⁴⁹ The commission delivered a two-volume report that provided an insightful critique of inefficient labor practices mostly at underground mines still using the bord and pillar production method and government-imposed monopoly fees on users of government-owned ports and rail networks.

¹⁴⁸ Although the average FOB price of Australia's black coal exports increased by 16 percent per year between 2004 and 2007, price changes of this magnitude were not immediately recognized as a structural change in the industry. The industry had experienced stable or declining prices for so long that few were willing to second-guess historic price trends based on one or two years of price increases.

¹⁴⁹ Productivity Commission, 1998 "The Australian Black Coal Industry" Inquiry Report, AusInfo, Canberra.

Figure 16: Changes in Nominal and Real Prices of Australian Black Coal in A\$ per Tonne, 1987-2007



Source: Joint Coal Board, “Black Coal in Australia, 1986-87” Table 108, p. 104 for nominal price data.

Between 1987 and 1991, one might have easily missed the emerging competitive threats to Australia’s black coal industry. In absolute terms, Australia’s black coal industry continued to expand with increases in saleable coal production above 10 mtpa for four out of those five years. Moreover, coal mining companies were able to continue to reap profits by utilizing the spare capacity resulting from past investments in transportation infrastructure and mine capacity. Finally, Indonesian and Chinese competitors had not yet entered the export market in a significant way.

By 1997, the year that the Asian Financial Crisis broke, it was impossible to ignore reality any longer. Growth in coal exports had slowed dramatically from 16 percent per year during the rapid growth phase to less than 4 percent between the first 10 years of the competitive phase (1987-1996). Over the same 10-year period, real FOB prices for Australia’s black coal exports had tumbled by 16 percent. Although worker output per hour had improved by 40 percent between 1987 and 1996, a significant portion of the productivity gains were likely offset by higher wages and costs of materials and other inputs to the mining process.¹⁵⁰

¹⁵⁰ Joint Coal Board/Queensland Coal Board, “1996 Australian Black Coal Statistics,” Table 21, p. 20. The JCB stopped publishing statistics on average earnings of mine workers in the NSW coal mining industry after 1982 and one can only speculate that productivity gains were offset by higher nominal wages.

2.3.2 Supply-Side Factors

Up until the start of Asian financial crisis in 1997, supply-side factors seemed to be the only reasons for the slowdown in Australia's black coal exports. The two headline supply events were the massive decline in the price of oil due to the oil glut of the 1980s and the emergence, in 1995, of Indonesia as a major supplier of steam coal into the Asia Pacific region.¹⁵¹ From 1995 through 2003, Indonesian coal suppliers sold their coals to power companies located in North and Southeast Asia at a significant energy-adjusted discount to the delivered prices charged by Australian producers, which enabled them to take market share from Australian producers.

They were able to do so because of the low stripping ratios of their bituminous and sub-bituminous coal deposits and government-subsidized diesel prices that kept their cash costs of production very low. By offering its coals at a significant discount to Newcastle grade coals on an energy-adjusted basis and also allowing its customers to "capture the benefits" of any savings on transportation costs, Indonesia's coal producers were able to gain an increasing share of the Asian steam coal market over time. By 2006, Indonesia became the world's largest steam coal exporter in raw tonnage terms.

Over the competitive phase, the governments of NSW and Queensland were either unable or unwilling to expand their rail and port infrastructure quickly enough to allow them to fully compete for those markets. Indonesia, on the other hand, had a more flexible inland transportation system dependent on river barges, trucks, and floating transshipment facilities, which were easily expandable on an annual basis, allowing Indonesian suppliers to quickly ramp up production over the past two decades.¹⁵²

2.3.3 Exchange Rate Effects

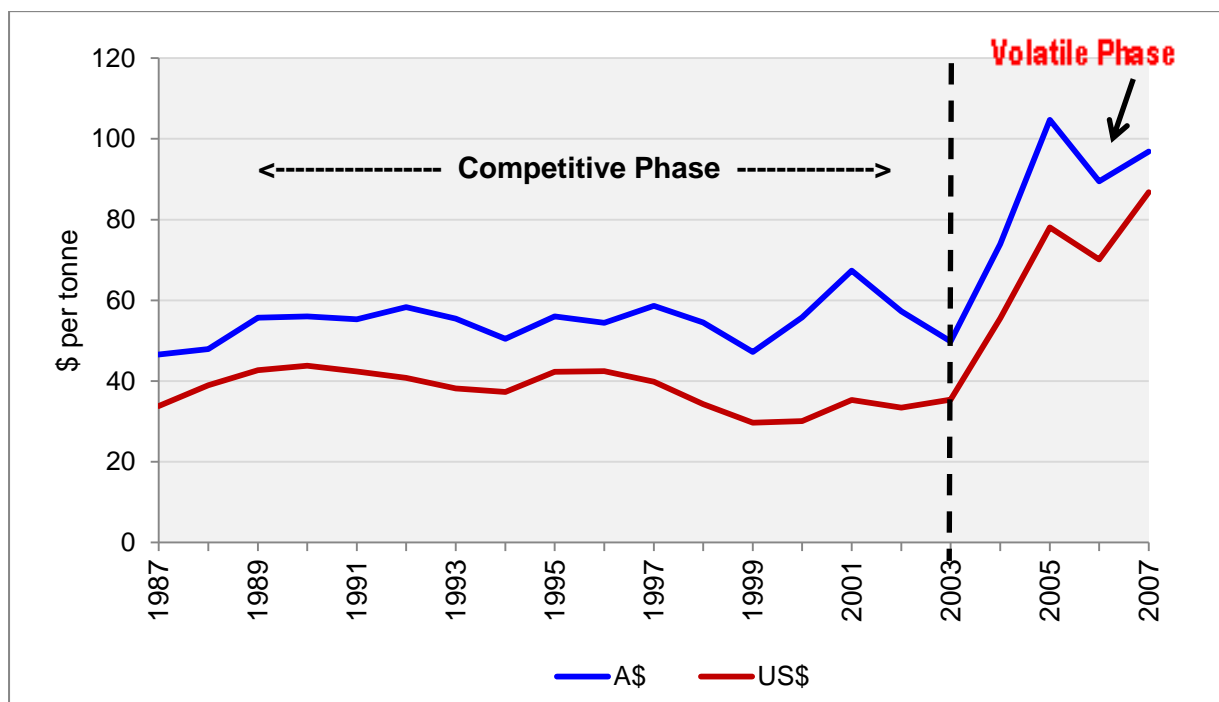
Except for the three-year period when the region was affected by the Asian Financial Crisis (1998-2001), exchange rate movements do not appear to have had much effect on the volatility of FOB prices for Australian black coal during the competitive phase (Figure 17). The jumps in price during the volatile price phase can be almost entirely attributed to other aspects of

¹⁵¹ Lucarelli, Bart, "The History and Future of Indonesia's Coal Industry: Impact of Politics and Regulatory Framework on Industry Structure and Performance," (Program for Energy and Sustainable Development, Stanford University) Working Paper #93, July 2010.

¹⁵² Ibid.

demand and supply for black coal exports, such as strong demand for steam coal from China and chronic transportation infrastructure constraints and weather-related events.

Figure 17: FOB Price Performance of Australian Black Coal Exports in A\$ and US\$ per Tonne, 1987 – 2006 (average price for all exports)



Source: Coal Services Pty. Ltd./Queensland Department of Mines and Energy “1996 Australian Black Coal Statistics” Table 40, p.38 for data from 1987 to 1995 and “2006 Australian Black Coal Statistics” Table 42, p. 39 for data from 1996 to 2006.

2.3.4 Continued Application of New Mining Technology

The application of new mining technology in Australia continued during the competitive phase. For example, underground mines in NSW increased their production of raw coal “from long wall faces” from 16.6 mt in 1986 (32 percent of total underground coal production) to 36.4 mt (77 percent of underground production) by 2003.¹⁵³ But open-cut mining was clearly the mining method of choice for those deposits that were amenable to open-cut mining.

Between 1986 and 2003, saleable coal produced from all Australian open-cut mines increased from 98 mt to 219 mt respectively.¹⁵⁴

¹⁵³ Joint Coal Board, “Black Coal in Australia, 1986-87,” Table 19, p. 22 and Coal Services Pty., Ltd./Queensland Department of Mines and Energy, “2006 Australian Black Coal Statistics,” Table 13, p. 11. (Note: 2003 and 2006 figure for all of Australia was 72.6 mt, 90 percent of underground production, and 80.9 mt, 91 percent of underground production, for 2003 and 2006 respectively.)

¹⁵⁴ Ibid.

2.3.5 Changes to the Coal Industry Regulatory Framework

During the competitive phase, the governments of NSW and Queensland made a number of important changes to their coal mining regulatory frameworks for NSW and Queensland. In the case of Queensland, the state Parliament passed the Mineral Resources Act 1989, which was assented to in 1990 and signed into law in 1992. The Parliament of NSW passed similar legislation in 1992, titled the Mining Act of 1992. These acts, which were passed mostly in response to the move to large open-cut mining projects in Queensland and NSW during the late 1960s and through the 1970s, allowed for the allocation of larger coal exploration blocks and mining areas and for the provision of community services, taking away most of the need for government-to-business (G-T-B) agreements.¹⁵⁵

In addition, by the late 1980s, both NSW and Queensland were financially strong and their state-owned rail and port companies were able to support infrastructure expansion on their own. A mining company's requirements for participating in the development of new infrastructure were now handled via business-to-business (B-T-B) agreements between the mining company and the government-owned corporations that operated the rail and port networks. These B-T-B agreements were entered into without the state guarantees being required from government-owned rail and port corporations.

Other regulatory changes included the 1993 passing into law of the Commonwealth Native Title Act, which required holders of mining tenements to conduct negotiations with native land holders (aboriginal persons) on just compensation and other matters related to native land rights.¹⁵⁶ Other laws related to the allocation of water rights and environmental impact assessments were either passed or amended during the competitive phase and required amendments to the Queensland Mineral Resources Act of 1989 and the NSW Mining Act of 1992.

Significant changes to regulatory bodies also occurred during the competitive phase. By the start of the competitive phase, Australia's black coal industry had matured to a point where there was no longer a need for industry-specific regulatory bodies, such as the JCB, the CIT, the QCB, and the Mines Rescue Board, with broad mandates to regulate levels of production,

¹⁵⁵ The Queensland Mineral Resources Act 1989 covered all topics and regulatory issues related to the exploration for mineral resources, awarding of licenses, and development of mines. Health and safety matters were still handled under the Coal Mining Act 1925, which remained in force until 1999, when it was repealed and replaced by the Coal Mining Safety and Health 1999.

¹⁵⁶ http://www.dfat.gov.au/facts/indigenous_land_rights.html.

pricing, and technology adoption for Australia's black coal industry. The CIT and QCB were dissolved in the late 1990s. The functions of the QCB were taken over by Queensland's Department of Mines and Energy and the CIT's functions were folded into the appropriate labor relations agencies of the Commonwealth and NSW governments. However, the JCB managed to last until 2002, when it too was dissolved and its remaining functions transferred to Coal Services Pty. Ltd., a newly formed agency owned by the NSW coal industry.¹⁵⁷ Coal Services functions were limited to workers' compensation, occupational health and rehabilitation, and mines rescue services to the New South Wales coal industry.¹⁵⁸ It also has responsibility for compiling black coal statistics and selling them in report form to interested parties.

One other significant change to the regulatory framework during the competitive phase resulted from the successful asset privatization (asset sales) by the governments of NSW and Queensland of their port and rail systems. In 2002, the NSW government allowed private companies to own and operate rolling stock on its fixed rail lines. The bulk of NSW's freight rail network is now being operated by Asciano, a private company traded on the ASX, under a long-term lease with the government of NSW.¹⁵⁹

2.3.6 Industry Concentration

Four large coal producers—BMA, (BHP-Billiton and Mitsubishi Development), Rio Tinto, Xstrata, and Anglo American—have accounted for most of the country's saleable black coal production and exports since 2001. These four large companies, referred to in the coal industry as “the Big Four,” increased their production, exports, and control over recoverable black coal reserves primarily through acquisitions, with the objective of achieving economies of scale in the mining, distribution, and marketing of black coal.¹⁶⁰

With respect to their acquisitions, the largest acquired assets were those of the major oil companies—Shell, Arco, Exxon, and MIM Holdings.¹⁶¹ These four companies, along with Peabody Coal and Coal and Allied Industries, sold their coal assets to the Big Four between

¹⁵⁷ National Archives of Australia, “CA 154, Joint Coal Board” (http://naa12.naa.gov.au/SearchNRRetrieve/Interface/DetailsReports/AgencyDetail.aspx?reg_no=CA%20154). The NSW Minerals Council and the miner union, CFMEU, each own 50 percent of Coal Services.

¹⁵⁸ Ibid.

¹⁵⁹ Asciano is a private company traded over the Australian Stock Exchange.

¹⁶⁰ Mimuroto, Yoshimitsu, Toru Kimura, and Koichi Koizumi, “Restructuring of the Coal Industry in Australia,” February 2004.

¹⁶¹ Ibid.

1997 and 2002, a time when prices for coal and other commodities were depressed and expected to remain so into the foreseeable future.¹⁶² It was also a time when CO₂ emissions from coal-fired power plants and global warming in general started to take center stage as an international environmental issue. As a result of these market and regulatory considerations, major oil companies decided it was best to focus on fossil fuel assets that had less exposure to climate change policies.

In 1997, Shell, Arco, Exxon, MIM Holdings, Peabody Coal, and QCT accounted for 20 percent of Australia's saleable black coal production while the Big Four accounted for only 38 percent of saleable production. As a result of their acquisitions and also through organic growth, the Big Four achieved a sizeable 64 percent share of Australia's production of saleable black coal by 2002.¹⁶³

2.4 Volatile Price Phase (2004-Present)

Despite a tightening of the Asian coal market in 2004, most analysts believed that the price of coal would remain subdued into the foreseeable future. The period from 1980 through 2003 was one in which prices for both coking and steam coals were either stable or declining (Figure 18).

2.4.1 Start of Asian Coal Price Volatility

After 2003, however, a very wide price differential developed in favor of coking coal. This increase in the coking to steam coal price differential caused supplies of PCI coals, which previously were being sold into the steam coal market, to be redirected back into the coking coal market due to the higher price they would earn if sold as PCI coals. These substitution effects added to the price volatility of steam coal over the period 2004-2009.

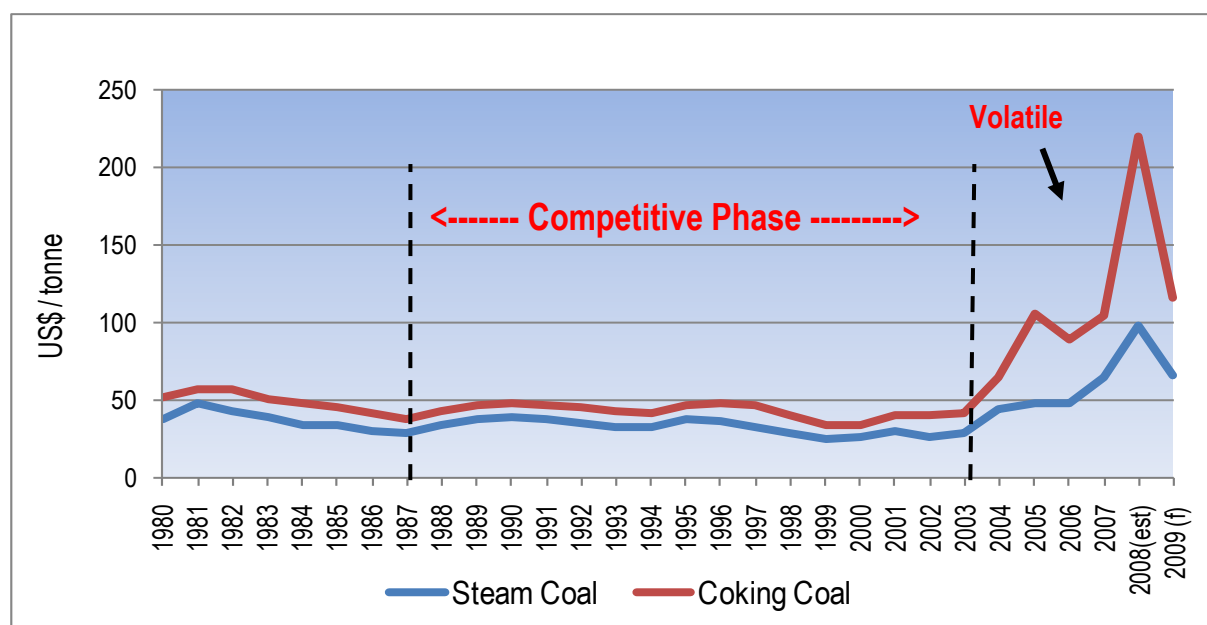
For both coking and steam coal, the largest price increases occurred between 2007 and July 2008. They were due to (a) sudden increases in steam coal imports by China on regional demand for steam coal; (b) the shutdown of nuclear power plants in Japan for safety reasons that created an unexpected increase in that country's demand for steam coal; and (c) supply

¹⁶² Ibid.

¹⁶³ Ibid, p. 3.

shortfalls in China, Australia, Indonesia, and South Africa due to exceptionally bad weather plus chronic rail and port infrastructure constraints in Australia.¹⁶⁴

Figure 18: FOB Prices for Australian Coking and Steam Coals, 1980-2009 in US\$/Tonne



Source: ABARE Commodity Statistics, 2001 and 2009

2.4.2 Exports

By the beginning of the competitive phase in 1987, Queensland increased its share of exports such that it had surpassed NSW in total production of saleable black coal.¹⁶⁵ Thereafter, Queensland and NSW were roughly equal in their annual production increases. In 2008, five years after the end of the competitive phase, Queensland accounted for 60 percent of Australia's black coal exports and NSW for the remaining 40% of black coal exports (see

¹⁶⁴ Other supply-side factors, which contributed to the large price increases between 2007 and mid-2008, are the following:

- The Indonesian government's removal in 2005 of price subsidies on diesel and fuel oil, which caused most Indonesian coal producers to experience significant increases in their costs of mining.
- The decline in the US\$ relative to the Australian \$ and the Indonesian rupiah caused the US\$ costs of Australian and Indonesian coal producers to increase. On average, over the period 2005 and 2008, the Australian \$ and Indonesia rupiah appreciated by 60 percent and 15 percent respectively against the US\$.
- Most Indonesian coal producers had "sold out" their low-cost bituminous and sub-bituminous coal reserves and were starting to develop new resources with lower CVs, located further inland without transport infrastructure but with higher stripping ratios than existing coal reserves.

¹⁶⁵ In 1987, Queensland produced 70.6 mt (48 percent) of black coal versus NSW's 70.1 mt (47 percent). See Joint Coal Board, "Black Coal In Australia, 1997-98, June 1999," Table 9, p. 8.

Figure 19).¹⁶⁶ In 2008, steam coal exports reached 132.4 mt and 50% of total black coal exports, up from 102.2 mt and 45% of black coal exports in 1987.¹⁶⁷

Although the shift in exports was from coking coal to steam coal over this period, Queensland still remained largely a producer of coking coal, which made up 74 percent of its exports. But this is likely to change over the next decade once Hancock Coal, Waratah and Bandana (Galilee Basin) and Xstrata and Syntech (Surat Basin) bring their vast deposits of steam coal into production between 2013 and 2015.

Japan remained Australia's largest single export customer into the volatile price phase, accounting for 42 percent of 2008 black coal exports.¹⁶⁸ However, by 2008, in an unexpected reversal of positions, Japan relied on Australia for around 70 percent of its black coal imports.¹⁶⁹ Significant growth in demand from Korea and Taiwan resulted in these two countries accounting for 27 percent of Australia's 2008 black coal exports.¹⁷⁰ More recently, starting in 2009, demand by China and India for Australia's hard coking coal has contributed to the shift in market share away from Japan and over to other Asian destinations. But these two countries have had very little impact on steam coal exports from Australia. Thus far, India and China have relied on Indonesia as their source of imported steam coal based on both price and quality considerations.

¹⁶⁶ In 2000, Australia's production of saleable black coal was 257.5 mt, of which 193.4 mt was exported.

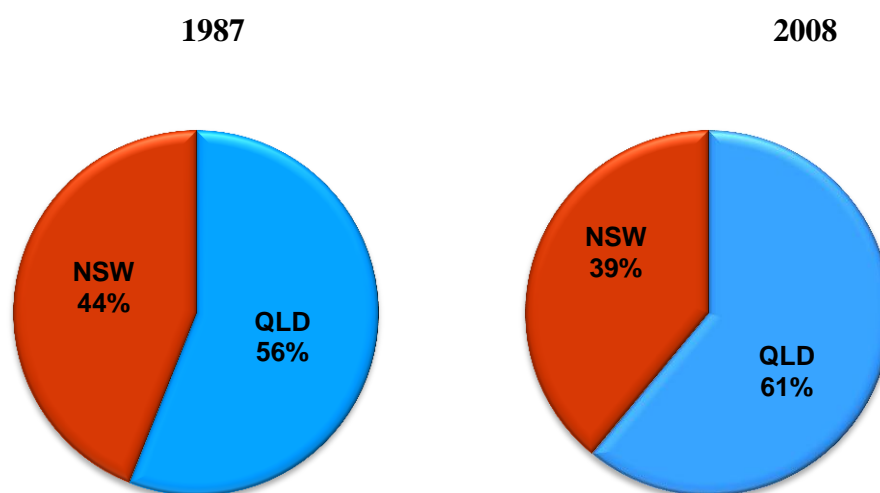
¹⁶⁷ Coal Services Pty. Ltd. and Queensland Department of Employment, Economic Development and Innovation, "Australian Black Coal Exports," page 1 (issued April 2010) and Joint Coal Board/The Queensland Coal Board, Australian Black Coal Statistics, 1989, Table 24, page 30.

¹⁶⁸ Coal Services Pty Ltd. "Australian Black Coal Exports", Issued April 2010.

¹⁶⁹ ABARE, "Commodity Report" April 2010.

¹⁷⁰ ABARE, "Australia's Mineral Statistics, 2010," December Qtr 2009, Table 9, p. 17.

Figure 19: Queensland and NSW Shares of Black Coal Exports, 1987 and 2008



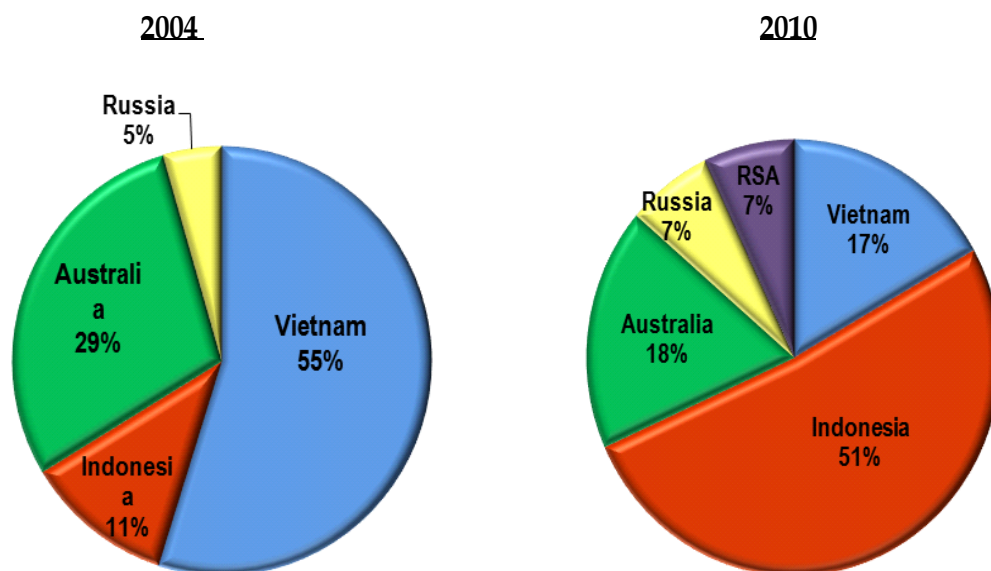
Source: Joint Coal Board/Queensland Coal Board, “1996 Australian Black Coal Statistics,” Table 28,p.26
ABARE, Australian Commodity Statistics, 2008.

2.4.3 Impact of China and India on Australia’s Export Markets

China’s imports of Australian black coal—both coking and steam coal—were scarcely noticeable until 2009, when they tripled 2008 levels to reach 130 mt. China’s coal imports increased further in 2010 to reach 165 mt. Prior to 2009, China’s main impact on Asian coal markets was the reduction in its exports of both steam and coking coal to Taiwan, Korea, Japan and the Philippines.

Figure 20 shows the massive increase in Indonesia’s share of China’s steam coal imports and the decline of Australia’s and Vietnam’s shares of Chinese steam coal imports between 2004 and 2010. Indonesia’s dominant position in China’s steam coal import market is expected to be maintained through 2015.

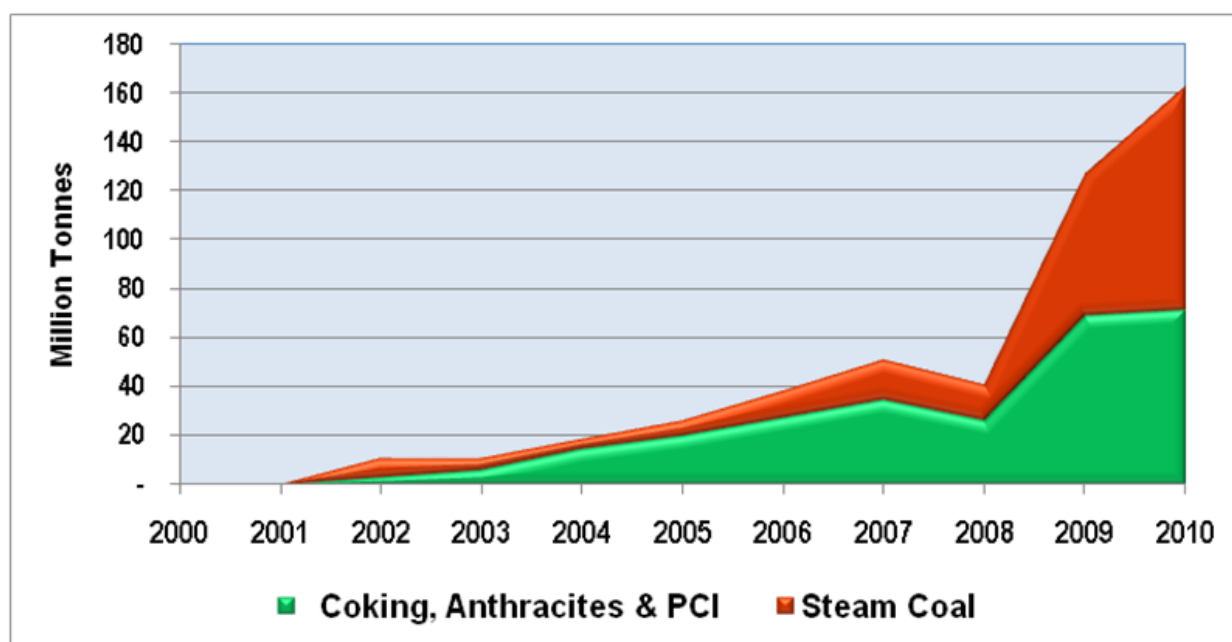
Figure 20: Coal Exporter Country Shares of China's Steam Coal Imports ^Ω



^Ω Vietnam's exports of anthracite to China are assumed to be used for power generation and therefore included in the category of steam coal. **Source:** China Coal Statistics, Export Information Administration

Figure 21 shows China's imports of coking coal and steam coal between 2000 and 2010. China's imports of both coking and steam coal occurred in 2009. If not for China, FOB prices for steam and coking coal would have collapsed much below the \$60- \$70/t price that prevailed for Newcastle grade coal in early 2009.

Figure 21: Chinese Imports of steam and coking coal between 2000 and 2010



Source: China Coal Statistics, Export Information Administration

Although the Chinese steel industry experienced robust growth between 2004 and 2008, its members procured most of their coking coal requirements from domestic suppliers until 2009 when, in response to very attractive FOB prices for Australian coking coals and the very low costs of chartering Panamax and Cape-size vessels, the Chinese mills increased their purchases of hard and soft coking coals from Australia from 1.3 mt of coking coal in 2008, which was less than 1% of Australia's total coking coal exports, to 31.1 mt in 2009, or 23% of its total coking coal exports.

Australia's exports of steam coal to China increased from 2.2 mt or 2% of total steam coal exports in 2008 to 16 mt or 12% of total steam coal exports in 2009 before declining to 13.4 mt and 10% of total exports in 2010 due to higher prices. (Table 2)

Table 2: Chinese Imports of Australian Coking and Steam Coals and Percent Share of Total Australian Exports (in million tons and percent share) (2004 -2010)

Year	Australian Coking Coal			Australian Steam Coal		
	Chinese Imports (mt)	Total Exports (mt)	Chinese Share of Total Exports (%)	Chinese Imports (mt)	Total Exports (mt)	Chinese Share of Total Exports (%)
2004	4.24	117.18	3.6%	2.22	107.35	2.1%
2005	3.60	123.83	3.0%	1.95	109.84	1.8%
2006	2.11	124.10	1.7%	5.40	113.20	4.7%
2007	2.42	137.93	1.8%	1.50	112.50	1.4%
2008	1.32	135.29	1.0%	2.30	126.00	1.8%
2009	31.06	135.06	23.0%	16.00	136.10	11.7%
2010 ^Q	17.39	129.88	13.4%	13.40	138.76	9.7%

^Q 2010 figures over the months January-October 2010 only.

Source: Energy Publishing, “Australian Coal Reports,” February 2006, 2007, 2008, 2009 and December 2010.

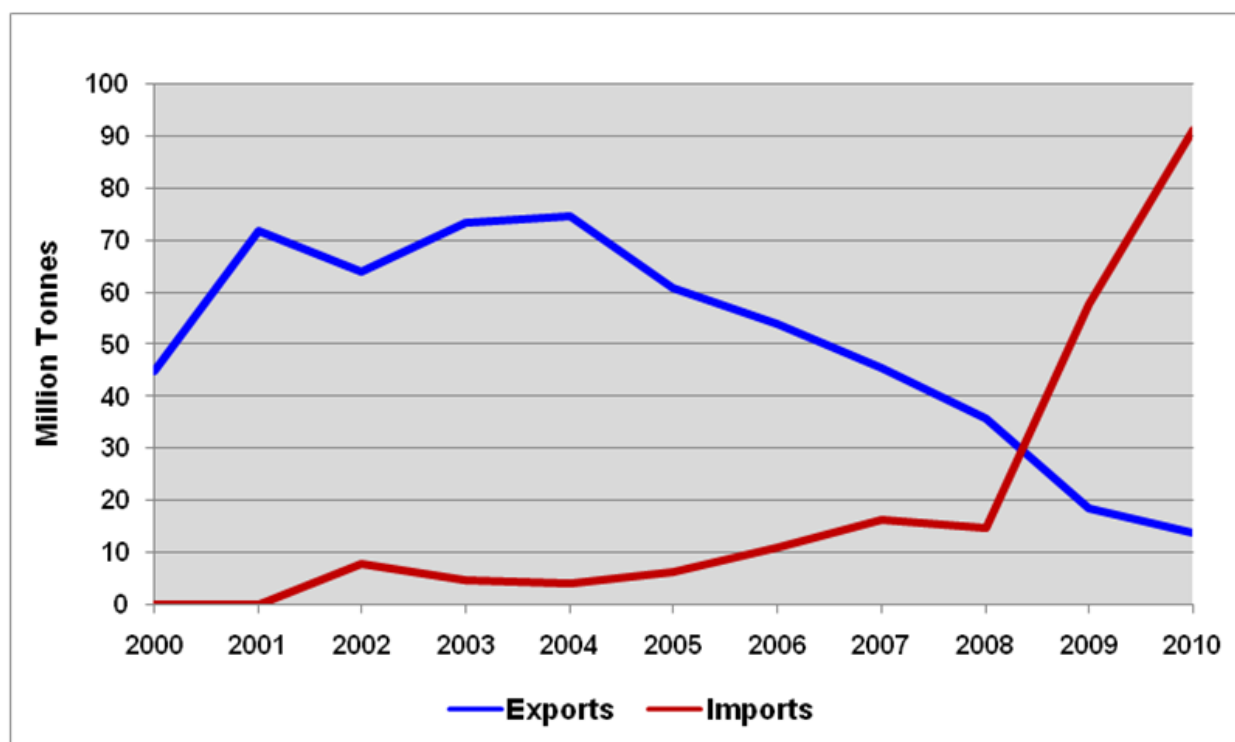
Indonesian coal producers, on the other hand, experienced spectacular growth in their exports to China between 2008 and 2010 with Indonesia’s steam coal exports to China increasing from 10.9 mt in 2008 to 52.8 mt in 2010. (Table 3) China’s reliance on Indonesia for over 50% of its coal imports may seem like an unhealthy dependency on a single country. But if looked at as a percent of China’s 2010 steam coal consumption, the dependency is close to nil – less than 2% of total consumption.

The very large increases in China’s coal imports for the years 2009 and 2010, was accompanied by its progressive reduction in steam coal exports from 74.6 mt in 2004 to an estimated 13.8 mt in 2010. These two shifts in coal imports and exports, which are shown in Figure 22, have contributed greatly to price increases and price volatility in the region. Over the same period, imports of steam coal skyrocketed from 4 mt in 2004 to an estimated 91.2 mt in 2010 (Figure 22).

Table 3 Chinese Imports of Indonesian Steam Coal, 2004-2010							
	in million tons				Chinese Imports of Indonesian Steam Coal as a % of		
Year	Indonesia	All Countries	Total Indonesia Exports	China Coal Consumption	Total Chinese Steam Coal Imports	Total Indonesian Coal Export	Chinese Coal Consumption
2004	1.3	4.0	105.4	n/a	32%	1%	n/a
2005	2.4	6.1	117.2	1,816	39%	2%	0%
2006	4.9	11.0	146.0	1,965	45%	3%	0%
2007	13.6	16.4	163.5	2,073	83%	8%	1%
2008	10.9	14.6	158.0	2,295	74%	7%	0%
2009	28.7	57.8	176.4	2,640	50%	16%	1%
2010	52.8	91.2	190.0	3,036	58%	28%	2%

Sources: China Coal Statistics, Export Information Administration (for Indonesian and All Countries coal import data), Energy Publishing, Indonesia Coal and Power Report, 2004-2010 (for Total Indonesian Exports); IEA Coal Information 2010 (for China Coal Consumption)

Figure 22 China's steam coal imports and export, 2000-2010 (in million tons)



Source: China Customs Statistics, Export Information Administration,

Chinese coal buyers are highly opportunistic. They tend to enter and exit from the coal import markets based on price alone. With the higher coal prices that have prevailed for both coking and steam coals from January 2010 onward, it is surprising that China's imports of Australian

coal from January to October 2010 are significantly higher on an annualized basis than imports for all of 2009. But this may merely reflect a lag in the market response to higher prices that will lead to a substantial reduction in Chinese coal imports during the first half of 2011.

India, for its part, has over the past decade accounted for a very large and growing share of Australia's hard and semi-soft coking coal exports. For example, between 2004 and 2010, India increased its share of Australia's coking coal exports from 13% (2004) to 21% (2010). (Table 4) But because India only increased its coking coal imports at a moderate growth rate each year, it never had a noticeable effect on FOB export prices for coking coal.

India's steam coal imports from Australia have been small and declining since 2004 and are not expected to increase in a very dramatic fashion due to high shipping costs and premium values that those coals can earn in other export markets. Australian steam coal exports to India declined from 1.27 mt in 2004 (1.2% of Australia's total steam coal exports) to 0.45 mt in 2010 (0.3% of Australia's total steam coal exports) (Table 4).

Table 4: Indian Imports of Australian Coking and Steam Coals and Percent Share of Australian Exports (in million tons and percent share)

Year	Australian Coking Coal			Australian Steam Coal		
	Indian Imports (mt)	Total Exports (mt)	Indian Share of Total Exports (%)	Indian Imports (mt)	Total Exports (mt)	Indian Share (% of Total Exports)
2004	15.23	117.18	13.0%	1.27	107.35	1.2%
2005	14.10	123.71	11.4%	1.48	109.92	1.4%
2006	14.71	124.10	11.9%	1.09	113.2	1.0%
2007	21.61	137.93	15.7%	0.51	112.5	0.5%
2008	24.72	135.29	18.3%	0.90	126.0	0.7%
2009	26.58	135.06	19.7%	0.60	136.1	0.4%
2010	27.25	156.28	17.4%	0.45	138.76	0.3%

Source: IEA, 2010 Coal Information.

India prefers steam coals from Indonesia based on price and quality factors. Indonesian coals have qualities that make them more suitable as a blending stock for existing Indian power plants than Australian steam coals plus they are significantly cheaper on a \$/GJ basis. In particular, Indonesia's coals have low to medium CVs with high to medium moisture contents and low ash and sulfur contents while domestic coals have very low CVs, high ash and low

moisture contents. Australian steam coals, which sell at an FOB premium to Indonesian coals, have a higher ash content (around 8 percent) than the Indonesian coals (around 3 percent to 5 percent by weight). As a result of this quality preference and the lower \$/GJ price for Indonesian steam coals relative to Australian steam coals, Indonesia's exports of steam coal to India have increased smartly since 2005 (Table 5). Its exports to India are expected to increase at an even greater growth rate over the next decade.

Table 5 Indian Imports of Indonesian Steam Coal, 2004-2010							
	in million tons				Indian Imports of Indonesian Steam Coal as a % of		
Year	Indonesia	All Countries	Total Indonesian Coal Exports	Indian Coal Consumption	Steam Coal Imports from All Countries	Total Indonesian Coal Exports	Indian Coal Consumption
2004	n/a	n/a	105.4	n/a	n/a	n/a	n/a
2005	13.9	21.7	117.2	391.7	64%	12%	4%
2006 (est)	18.3	26.2	146.0	418.8	70%	13%	4%
2007	22.7	30.7	163.5	454.1	74%	14%	5%
2008	20.7	31.0	158.0	498.8	67%	13%	4%
2009	25.1	44.3	176.4	536.3	57%	14%	5%
2010 (est)	30.5	63.3	190.0	575.7	48%	16%	5%

Sources: IEA, 2010 Coal Information except "Total Indonesian Coal Exports" figures which were obtained from Energy Publishing, Indonesian Coal and Power Report.

2.4.4 Impact of Volatile Prices on Investment Decisions

In late 2008, the United States and Europe went into a deep economic recession due to the collapse of the housing and mortgage derivatives markets in the United States. For a short time, it led to a massive decline in the prices of coking and steam coals. Since mid-2009, black coal prices have recovered quite a bit of their lost ground. For the week of January 7, 2011, the globalCOAL Newcastle Price Index stood at \$129.90 per tonne, still a far cry from the July 2008 peak price of \$184 per tonne.¹⁷¹

The volatile price movements for Australia's black coal exports after 2003 have served to complicate the long-term investment decisions of Australia's coal mining companies, the governments of NSW and Queensland, and Australia's black coal export customers. The result

¹⁷¹ <http://www.globalcoal.com/>

has been “stop-and-go” decisions with mining companies and state governments making “firm” decisions in 2008 to proceed with large mining projects and related transport infrastructure projects one month and then in early 2009 reversing those decisions due to changes in market conditions and financial constraints.

Although weather-related events created short-term price impacts during 2008, coal exports were never seriously disrupted in the region. This was partly due to the maintenance of stockpiles at ports, coal mines, and power plants. To some extent, the price volatility was due to panic buying of coal as an over-reaction to weather-related events. Ample supplies of coal were available in the region to meet needs but admittedly those supplies were more evenly balanced against demand than had been the case in the past.

In late 2008 and through the first half of 2009, tight supply turned to oversupply before returning to a more balanced demand–supply situation from September 2009 through May 2010. And then during December 2010 and January 2011, heavy rains and flooding hit the coal mining industry of Queensland, causing black coal prices to increase by at least \$30 per tonne since October 2010.¹⁷² One can expect larger short-term increases to occur in response to the short-term weather-related supply disruptions. But, in the medium- and longer- term, implementation of new mine projects and expansions of the coal transport systems in Australia and Indonesia, if they occur according to plan, are expected to alleviate the short-term capacity constraints that are still being experienced throughout Asia.

2.4.5 Latest Data on Industry Concentration

As of 2008, the Big Four’s share of total saleable production had decreased to 61 percent, which was still very high level of concentration, given that we are considering only four coal producers (Figure 23).¹⁷³ Anglo, BMA, Rio Tinto, and Xstrata control most of Australia’s recoverable reserves of hard and soft coking coal. In 2009, BHP separately and through BMA-owned assets controlled 60 percent of the hard coal coking reserves located in the Bowen Basin of Queensland. An additional 20 percent of the Bowen Basin hard coking coal reserves are controlled by Anglo, Peabody, Rio Tinto, and Xstrata.¹⁷⁴ With respect to soft coking coal reserves, Xstrata and Rio Tinto controlled 45 percent and 25 percent of NSW’s recoverable

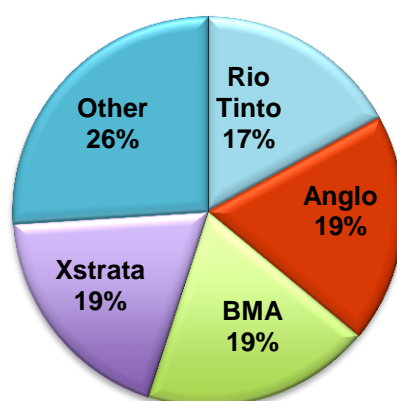
¹⁷² Ibid.

¹⁷³ Coal Services Pty., Ltd./Queensland Department of Mines and Energy, “2006 Australian Black Coal Statistics,” pp 12-16 and pp. 46-60.

¹⁷⁴ E-mail communication from Ron Sait of Geoscience Australia, Canberra, June 2010: More than 90 percent of Australia’s hard coking coal reserves are located in the Bowen Basin.

soft coking coal reserves as of December 2008.¹⁷⁵ Steam coal is much less concentrated but Xstrata owns Rolleston (8 mtpa), Anglo-American owns Callide (9 mtpa), and Rio Tinto owns Blair Athol/Clermont (12 mtpa).¹⁷⁶

**Figure 23: Australia’s “Big Four” Coal Producers (Anglo, BMA, Rio, and Xstrata)
Produced 74 Percent of Australia’s 2006 Saleable Black Coal**



Source: Coal Services Pty. Ltd./Queensland Department of Mines and Energy, “2006 Australian Black Coal Statistics,” Tables 14-17, pp. 12-16 and pp. 46-60.

One other outcome of the industry’s consolidation has been the move toward larger mines. In 1996, average saleable coal production per coal mine in Australia was 1.6 million tonnes per mine and only one mine produced more than 10 mtpa.¹⁷⁷ By 2006, a total of eight mines produced more than 10 mtpa of saleable coal with five of these eight large mines owned by the Big Four. The average saleable coal production per mine increased to 2.7 million tonnes and 3.2 million tonnes in 2002 and 2006, respectively.

The level of black coal industry concentration is extraordinarily high for any industry and is an indication of the regulatory ease with which acquisitions can be made in the Australian resource sector. Over the next few years, newcomers such as Hancock Coal, Waratah/First Resources, and Syntech may break into the thermal coal sector with very large coal mining operations that may reduce the current level of high concentration but will increase the average

¹⁷⁵ Ibid.

¹⁷⁶ Queensland Department of Mines and Energy website (www.dme.qld.gov.au).

¹⁷⁷ Joint Coal Board/Queensland Coal Board, “1996 Australian Black Coal Statistics,” pp. 7 and 8.

mine size. But it is just as likely that some if not all of these newcomers will be acquired by one of the Big Four. In summary, if the new mega-coal mines in the Galilee and Surat basins are brought into production as planned over the next three to five years, the average size of Australian coal mines and industry concentration for its steam coal segment are destined to increase significantly with or without further industry consolidation.

2.4.6 Rail Network Expansion and Privatization

Between 1987 and 2004, the governments of NSW and Queensland accomplished timely expansions of their rail networks, which allowed substantial increases in their exports of both coking and steam coal up until 2004. From 2004 onward, however, the governments of NSW and Queensland were unable to keep up with the rapid growth in demand by the coal industry for additional rail infrastructure, contributing to long vessel queues at the Port of Newcastle and later at Hay Point and even Gladstone. The rail constraints were significant contributors to increased coal price volatility in the region.

At the same time that rail network constraints were being experienced, coal freight rates were widely viewed as excessive. In 1998, the Commonwealth government's Productivity Commission challenged the state governments of NSW and Queensland and their state-owned railway corporations to improve their productivity and lower their costs of service to the coal industry. The Productivity Commission made two important recommendations with respect to rail freight:

- (a) State governments should discontinue the practice of setting rail freight rates for hauling coal at a level that allows the state railways to earn monopoly profits or the state government to collect implicit royalties above the legally mandated royalty rate.
- (b) State governments should encourage third-party access to fixed rail infrastructure and allow coal producers and other investors to own and operate rolling stock on the fixed rail network.

The government of NSW implemented most of the Productivity Commission's recommendation in 2002, when it reorganized its FreightCorp in preparation for its divestment to private investors. In that same year, the Commonwealth government and the government of NSW combined the Australian government-owned National Rail Corporation's freight operations and rolling stock with the NSW government's reorganized FreightCorp and in 2002 sold the combined assets to Toll Holdings and Patrick Corporation, which formed Pacific

National (PN) to operate and manage those assets.¹⁷⁸ In 2001 Lang Corporation changed its name to Patrick Corporation, which in 2006, was acquired by Toll Holdings in a hostile takeover. Toll then split itself into Toll and Asciano, which holds the combined Toll and Patrick shares of Pacific National Asciano is an ASX-listed company.

In 2009, PNR railed approximately 83 million tonnes of coal from the Hunter Valley, Southern and Western coalfields of NSW to domestic customers and to export customers through the Port of Newcastle and Port Kembla. It currently operates in all states and the Northern Territory and, prior to the November 2010 IPO of Queensland Rail, was Australia's largest private rail freight company.

PNR claimed that, in 2009, it delivered 93 percent of New South Wales's export coal and was Australia's second largest coal hauler. Queensland Rail is the largest. Within NSW, PNR operates more than the 650 km Hunter Valley rail network and the 400 km Western coalfields network. It also operates trains over the 260 km dedicated coal haul route from Leigh Creek to Port Augusta in South Australia.¹⁷⁹

In the case of Queensland Rail, the Queensland government vacillated for a number of years before implementing the recommendations of the Productivity Commission during the volatile price phase. Its delay was most likely motivated by the importance of the monopoly rents earned by Queensland's state government from Queensland Rail. However, on November 22, 2010, the government of Queensland took an historic step when it successfully conducted an IPO for 60 percent of Queensland Rail National (QR National). Shares sold at \$2.55 each, which was at the low end of the offer range (A\$2.50 - \$3.00).¹⁸⁰ A few months prior to the IPO date, a consortium of coal producers, known as the Queensland Coal Industry Rail Group (QCIRG) and representing 98 percent of Queensland's coal export business, proposed to the Queensland government that it be allowed to buy only QR National's Central Queensland

¹⁷⁸ See State Records Archive Investigator, "FreightCorp" (<http://investigator.records.nsw.gov.au/Entity.aspx?Path=%5CAgency%5C1079>). and History of Patrick Corporation at <http://www.patrick.com.au/index.php?id=49>. Patrick Corporation was named Lang Corporation until October 2001.

¹⁷⁹ www.pacificnational.com.au.

¹⁸⁰ Bloomberg Businessweek, "QR National Climbs in Sydney after A\$4.05 Billion IPO," November 22, 2010 (www.businessweek.com/news/2010-11-22/qr-national-climbs).

fixed coal rail network for A\$4.5 billion. This proposal was withdrawn by QCIRG after a few months of fruitless negotiations with the Queensland government.¹⁸¹

As of January 2011, the Queensland government still owns 40 percent of the newly privatized QR National. It plans to sell off another 15 percent of QR National in 2012. The company was sold off as an integrated railroad company with ownership of both the fixed rail networks and its rolling stock. However, as part of the sales arrangements, third parties such as major coal producers will be allowed to own and operate coal haul trains on the QR National fixed rail network. Large coal producers, such as BHP Billiton, Xstrata, and Rio Tinto, are considering buying their own rolling stock and hauling its coal to the ports from which they export their coals.¹⁸² Ironically, the Queensland government's effort to privatize its railroad business may eventually lead to a more vertically integrated black coal industry in Queensland, which will own the rolling stock and port facilities used to transport and export their coals.

QRNational currently comprises various operating divisions. QRNational Coal is the division responsible for the transport of coal within Queensland. Recently, it started a service to transport coal from mines in NSW to the Port of Newcastle.¹⁸³ In 2009-2010, QRNational Coal delivered 198.3 million tonnes of black coal to export ports in Queensland and NSW and directly to customers in both states.¹⁸⁴ Asciano, owner of PNR, has not taken this competition lightly. It recently announced that it has been awarded a contract by Anglo American to haul 16.5 mtpa of coal in Queensland with some deliveries beginning in 2010.¹⁸⁵ It plans to double its coal haul tonnage in Queensland over the next five years.¹⁸⁶

QRNational Coal is divided into two service arms known as (a) QRNational Coal (South) and (b) QRNational Coal (North):

- QRNational Coal (South) operates the Blackwater and Moura systems in Central Queensland, the West Moreton system in SE Queensland, and the Hunter Valley System in NSW. In 2009-2010, it delivered 91.4 million tonnes of coal from 42 mines

¹⁸¹ Energy Publishing Inc., "Coal Chain Australia" Issue 0013, November 2010, pp. 1-2.

¹⁸² Energy Publishing Inc., "Coal Chain Australia" Issue 0014, December 2010, pp. 2-3.

¹⁸³ www.qrnational.com.au/CoalFreight/Pages/CoalFreight.aspxwww.freight.qr.com.au.

¹⁸⁴ Ibid.

¹⁸⁵ Energy Publishing Inc., "Coal Chain Australia Weekly," Issue 34, June 15, 2010, p. 1.

¹⁸⁶ Energy Publishing, "Coal Chain Australia", Issue 0014, December 2010, pp. 2-3.

to six domestic customers and five export terminals, of which RG Tanna and Barney Point at Gladstone, Brisbane, and Carrington and Kooragang at Newcastle receive of the bulk of its deliveries. A small amount of coal was delivered to the Port of Hay Point. Its operating area covers 1 million square kilometers. It operates a mixture of electric and diesel locomotives.¹⁸⁷

- QRNational Coal (North) operates the Goonyella and Newlands rail systems, which service 24 coal mines in the central and northern Bowen Basin. In 2009-2010, it delivered 106.9 mt of black coal from 23 coal mines primarily to the coal export terminals located at Abbot Point, Dalrymple Bay, and Hay Point. Some portion of its coal deliveries are routed through the RG Tanna and Barney Point coal terminals located within the Port of Gladstone.¹⁸⁸

2.4.7 Chronic Port Constraints

Since 2004, the Port of Newcastle has dominated the news as Australia's most capacity-constrained port, with long lines of ships often queuing up for days at a time and incurring demurrage charges. However, from November 2009 through June 2010, DBCT and HPCT also suffered from problems that captured negative headlines. Vessel queues at Hay Point's DBCT ranged from 70 vessels in November 2009 and 29 days' average turnaround due to mechanical problems with one of the terminal's coal in-loaders.¹⁸⁹ In December 2009 and January 2010, bad weather kept vessel queues consistently above 50 days, which in turn led to vessels loading at DBCT experiencing higher than normal demurrage charges, ranging from \$4 per tonne to almost \$10 per tonne. In March 2010, cyclone Ului caused extensive damage to the Hay Point Coal Terminal forcing its closure from March 11 to April 2 and demurrage charges to jump above \$4 per tonne.¹⁹⁰

Gladstone and Newcastle, on the other hand, experienced much lower vessel queues and demurrage charges. Gladstone's RGTCT experienced rather light vessel queues of 5 to 24 vessels and demurrage charges well under \$4 per tonne. Newcastle experienced moderately high vessel queues of 8 to 39 days but demurrage rates of under \$2.50 per tonne.¹⁹¹

¹⁸⁷ www.qrnational.com.au/CoalFreight/Pages/CoalFreight.aspxwww.freight.qr.com.au.

¹⁸⁸ Ibid.

¹⁸⁹ Energy Publishing Inc., "Coal Chain Australia Weekly," Issue 0001, November 2009, pp. 5-9.

¹⁹⁰ Energy Publishing Inc., "Coal Chain Australia Weekly," Issue 0004, February 2010, pp. 2-3, and Issue 0005, March 2010, pp. 1, 8.

¹⁹¹ Ibid.

The 2010/11 cyclone and rainy season had just begun at the time of publication but already excessive rains have led to closures of most open-cut mines in Queensland during December 2010 and the exhaustion of mine and port stockpiles.¹⁹² Lost tonnages are estimated to be running at 3 mt per week with extended speed reductions on the Goonyella and Blackwater lines, which carried over 130 mt of black coal in 2009/10. Many mines have already declared *force majeure* due to flooding of pits caused by the heavy rains.¹⁹³ A key question is what will happen between January 2011 and May 2011 now that the real rains have arrived and the cyclone season has begun. The outlook is for coal supplies from Queensland to experience greater weather-related disruptions than had been experienced in 2008, which was the year when the price of Newcastle grade coal reached \$184 per tonne.

The main point illustrated by these figures is that Australia's annual coal exports can be affected significantly in the short term by weather-related conditions that limit rail speed and port loadings dramatically between December and May of each year. Worsening weather conditions are a factor that may increase in importance over the next two decades and should be viewed as a chronic issue, albeit one that is seasonal in nature. The longer-term, structural shortage of rail and port capacity over the past six years has had a lasting effect on the industry's level of new investments in mines and has limited Australia's coal exports over the past decade. Both factors are critical constraints that have played a large role in limiting the growth of exports in the past and are likely to do so into the foreseeable future.

2.4.8 Domestic Consumption

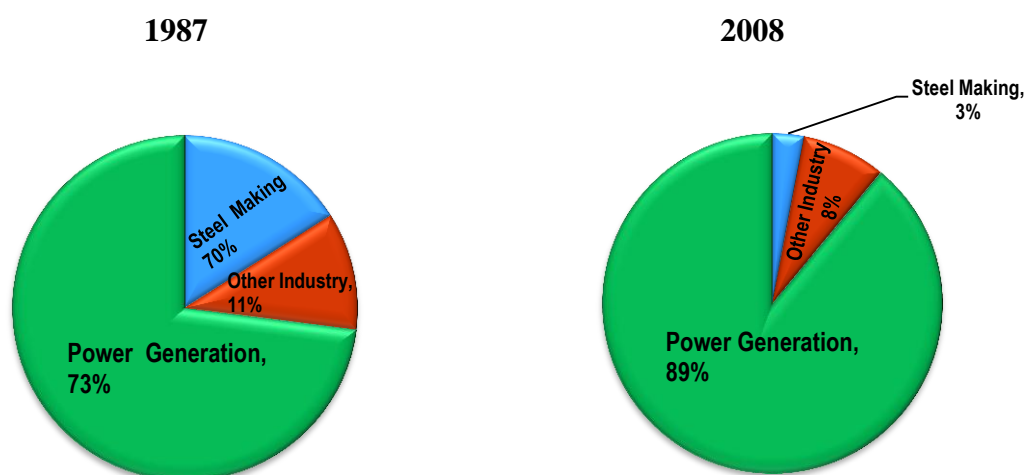
During the competitive and volatile price phases, Queensland continued to increase its domestic consumption of black coal, both in absolute terms and as a percentage of total domestic consumption. Queensland's domestic consumption, which stood at 12.2 mt or 26 percent of Australia's black coal consumption in 1987, reached 31 percent of Australia's black coal consumption (23.4 mt) in 2008.¹⁹⁴ By the end of 2008, steam coal (power generation + other industry) accounted for 97 percent of domestic black coal consumption, up from an 84 percent share in 1987. The main user of steam coal was the power industry, which in 2008 consumed 89 percent of domestically used black coal, up from 73 percent in 1987 (Figure 24).

¹⁹² Energy Publishing, "Australia Coal Report", December 2010, pp. 2-3.

¹⁹³ Ibid.

¹⁹⁴ Joint Coal Board and Queensland Coal Board, "1996 Australian Black Coal Statistics," Table 44, page 42, and Coal Services Pty. Ltd. (data supplied via e-mail, March 2010).

Figure 24: Domestic Consumption of Black Coal by Industry, 1987 and 2008



Source: Joint Coal Board/Queensland Coal Board, “1996 Australian Black Coal Statistics,” Table 43, p.41.

Coal Services Pty. Ltd./Queensland Department of Mines and Energy, “2008 Australian Black Coal Statistics” (pending).

Almost all of Queensland’s black coal usage was steam coal used for power generation. In the case of NSW, black coal use increased from 24.6 mt in 1987 to 32.3 mt in 2000. Similar to Queensland, the increased use of black coal was of steam coal.¹⁹⁵ Over this period, NSW decreased its use of coking coals by 800,000 tonnes. Other states also generated a significant increase in black coal usage that was totally steam coal used for power generation.

2.4.9 Regulatory Frameworks as of January 2011

Both NSW and Queensland have comprehensive and time-proven legal frameworks for allocating areas for exploration and development of new coal mines. They also have clear regulatory procedures and frameworks for developing new rail and port infrastructure projects and managing labor relations, mine safety, and matters that infringe upon international relations.

These mature frameworks do not appear to have significantly constrained the expansion of steam coal production in either state. Complaints by coal producers tend to concentrate around two topics: (a) the slow pace of implementing requests for project approval, a common complaint in any jurisdiction where conflicting interests need to be considered before a public

¹⁹⁵ Ibid.

decision can be made, and (b) the reversal of key decisions at the first sign of economic adversity.¹⁹⁶

Although the state of Queensland is described by a number of industry sources as a more attractive regulatory venue than NSW for developing new coal mines, its state bureaucracy is also criticized for not showing the political will and courage to make controversial decisions, with the two examples most frequently cited as follows:¹⁹⁷

- Slowness in resolving overlapping claims between the separate industries of coal mining, CBM extraction and UCG production
- Delays in approving new port and rail projects and then not holding to those decisions in the face of short-term changes to the domestic economy¹⁹⁸

In the case of NSW, the same sources claimed that the NSW's government bureaucracy is less friendly to miners. The regulatory process in NSW has been described by a number of sources interviewed as an adversarial process that creates a much higher level of investor uncertainty than coal miners have experienced in Queensland.

But, in general, the regulatory frameworks in both states operate with a reasonable degree of efficiency and equity. Government agencies responsible for implementing the laws and regulations largely reach decisions that the industry views as fair and balanced. The rules and regulations are subject to public comment at reasonable intervals and the most important aspect of implementing either a new coal mine or a rail or port project—the review and approval of a project's environmental impact statement (EIS)—allows for the public to provide its comments over a six-week period from the date that the EIS is submitted to the Office of the Coordinator General (OCG), the government entity responsible for overseeing any significant infrastructure or mining project.¹⁹⁹

¹⁹⁶ Confidential interviews with a number of coal producers during August 2008.

¹⁹⁷ Ibid.

¹⁹⁸ Ibid. This second “complaint” is probably of greatest concern from the perspective of sustainable coal supply from Australia as new mining projects will not go ahead without related port and rail projects being approved and under way.

¹⁹⁹ www.epa.wa.gov.au/ABOUTTHEEPA/EIAREVIEW/Pages/default.aspx

Public hearings on any EIS are organized by the project proponent who is required to provide a full and transparent response to any public comments.²⁰⁰ At the end of the public review period, the OCG makes a final decision on whether a project should be allowed to proceed on environmental grounds and whether additional conditions are to be attached to that approval.²⁰¹ In most cases, the project proponent is required to issue a supplemental EIS that states the actions the developer will take to address concerns raised by the public and deemed by the OCG as significant.

Once a coal mine is operating, issues related to worker safety are handled by the Coal Services Pty., Ltd., the successor to the Joint Coal Board, while health-related issues are handled by the mines departments of both state governments. Over the past 50 years, the JCB/Coal Services and the Queensland and NSW mines departments have successfully eliminated issues related to worker health and safety that previously led to strikes and other worker actions that led to significant losses in coal output prior to 1960.

As of December 2010, the regulatory issues of greatest concern to most coal mining companies are not the existing regulatory frameworks and the specific actions of state government bureaucrats. Instead, the primary concerns at this time are related to policies of the Australian Commonwealth government and in particular its proposals to pass into law:

- A carbon pollution reduction scheme (CPRS), which is a “cap-and-trade” scheme for reducing CO₂ equivalent emissions throughout Australia
- A 30 percent mineral resources rent tax (MRRT) on mining companies

Trade journals and Australia’s newspapers unanimously mention the CPRS and the MRRT as creating the greatest level of investment uncertainty at this time.

²⁰⁰ Ibid.

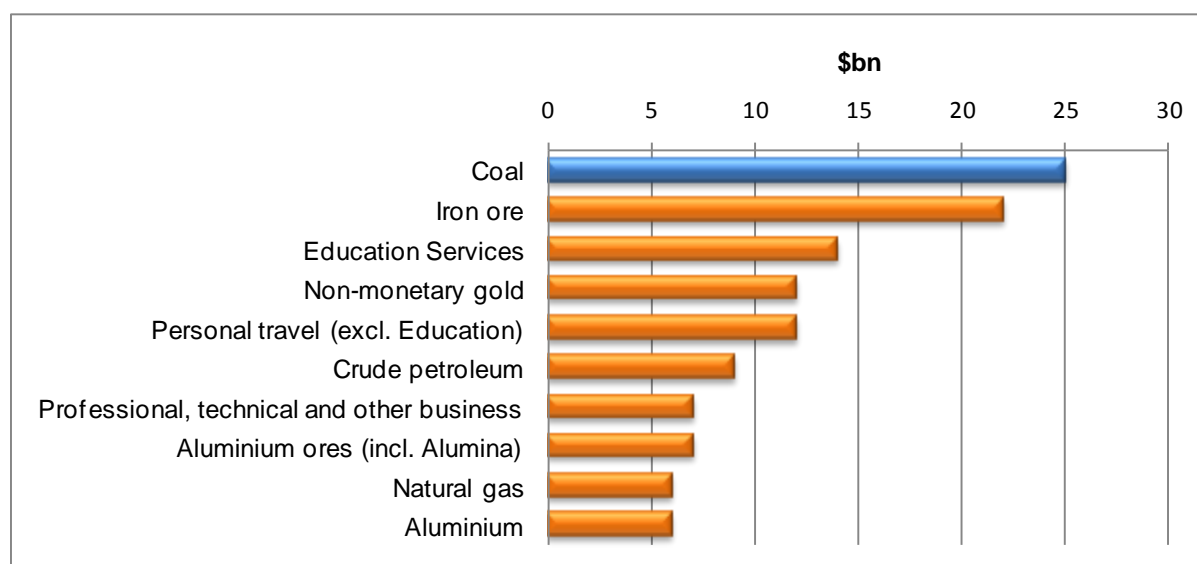
²⁰¹ Ibid.

3. Future Challenges and Issues

At the close of 2008, coal remained Australia's largest export earner and one of its largest employers. It is the one industry that can make or break the economies of NSW and Queensland. According to the Australian Coal Association (ACA), the black coal industry of Australia "directly employs more than 30,000 people, predominantly in New South Wales and Queensland. It's estimated that at least another 100,000 Australians are indirectly employed by the coal industry. In regional areas such as Queensland's Bowen Basin, coal is responsible for one in every four jobs. In the brown coal producing states such as Victoria, coal miners are employed by power companies and in industries such as aluminium smelting. Australians in all States provide services to the coal industry, including equipment, transport and insurance."²⁰²

While there may be some self-serving purpose as well as exaggerated claims in the ACA information, the dependence of the Australian economy on the coal sector is indisputable. The reality is Australia's black coal industry is Australia's single largest export earner and is a sector that has tremendous economic and by extension political clout in Australia (Figure 25).

Figure 25: Black Coal Was Australia's Largest Export Earner in 2008



Source: ACA Website

²⁰² "The Australian Coal Industry," australiancoal.com.au.

Queensland and NSW account for almost all of Australia's black coal production and all of its exports. Although these two states are contiguously located, significant differences exist between their coal industries with respect to (a) the types and quality of coal resources available; (b) the inland transport infrastructure systems that have been developed to support these industries; (c) the regulatory frameworks that have been developed to regulate both industries; and (d) the political environments within which these frameworks exist. But they both tend to face the same development issues that will affect their future levels of sustainable production with the following being the most important common issues:

- Resource and reserve depletion
- Rail and port infrastructure constraints
- Regulatory uncertainty caused by proposed legislation related to GHG reduction (CPRS) and new taxes on the mining sector (RSPT)
- Impacts that new technologies will have on the levels of production and types of energy products produced from remaining recoverable reserves²⁰³

3.1 Resources and Reserves Depletion

The Australian government's official estimates of coal resources and reserves are published annually by Geoscience Australia.²⁰⁴ It provides estimates of demonstrated resources—both economic and sub-economic—as well as JORC reserves for all mineral resources, including black and brown coal and CBM. Resource estimates are first expressed as demonstrated resources and then separated into economic and sub-economic demonstrated resources.²⁰⁵ Economic demonstrated resources (EDR) are those resources that Geoscience Australia concludes have either near-term or long-term potential to be developed economically. EDR of black coal are approximately three to four times greater than JORC black coal reserves, which are reported annually by publicly traded mining companies.

Geoscience Australia estimates that Australia had, as of December 2008, black coal EDR of 39.2 billion tonnes with the bulk of those reserves located in Queensland (56 percent) and NSW (40 percent). Both states also accounted for 100 percent of Australia's 2008 black coal

²⁰³ The regulatory uncertainty created by Australia's CPRS is only half of the story. The impact of GHG policies of the governments of Japan, Korea, Taiwan, and the rest of Asia, which in 2007 accounted for 89 percent of Australia's steam coal exports will largely decide the fate of Australia's black coal industry.

²⁰⁴ See Geoscience Australia, Canberra, "Australia's Identified Mineral Resources 2009" for the latest report. Available online from www.geoscienceaustralia.com.au.

²⁰⁵ Ibid.

exports (Table 4).²⁰⁶ At 2008 raw coal production levels (438 million tonnes), Australia has sufficient black coal EDR to last for 90 years.²⁰⁷ These estimates do not include the large black coal deposits being developed in the Galilee and Surat basins.

Table 6: Australia's Demonstrated Coal Resources and JORC Reserves at December 2008

Coal Type	Demonstrated Resources				Company+Estimates	
	Economic (EDR)	Accessible EDR (AEDR)	Sub-economic		Inferred Resources	JORC Reserves (% of AEDR)
			Para- marginal	Sub- marginal		
Black Coal						
- in situ	56.2	n/a	3.0	10.3	106.0	n/a
- recoverable	39.2	39.1	1.5	6.7	66.7	13.4 (34%)
Brown Coal						
- in situ	44.3	n/a	43.1	18.1	112.3	n/a
- recoverable	39.2	32.2	38.8	16.3	101.1	4.8 (15%)

Source: Geoscience Australia, Canberra, "Australia's Identified Mineral Resources, 2009," p. 5.

3.1.1 NSW Coal Resources

Geoscience Australia estimates that NSW had, as of December 2008, recoverable black coal EDR of 15.7 bt. The resources are contained in six basins: (1) Sydney-Gunnedah; (2) Hunter; (3) Gloucester; (4) Oaklands; (5) Newcastle; and (6) Western and Southern (Figure 26). Most of NSW's black coal EDR (35 percent or 13.7 bt of total black coal EDR) are located in the 500 km long, 150 km wide Sydney-Gunnedah Basin.²⁰⁸

²⁰⁶ Ibid, p.5.

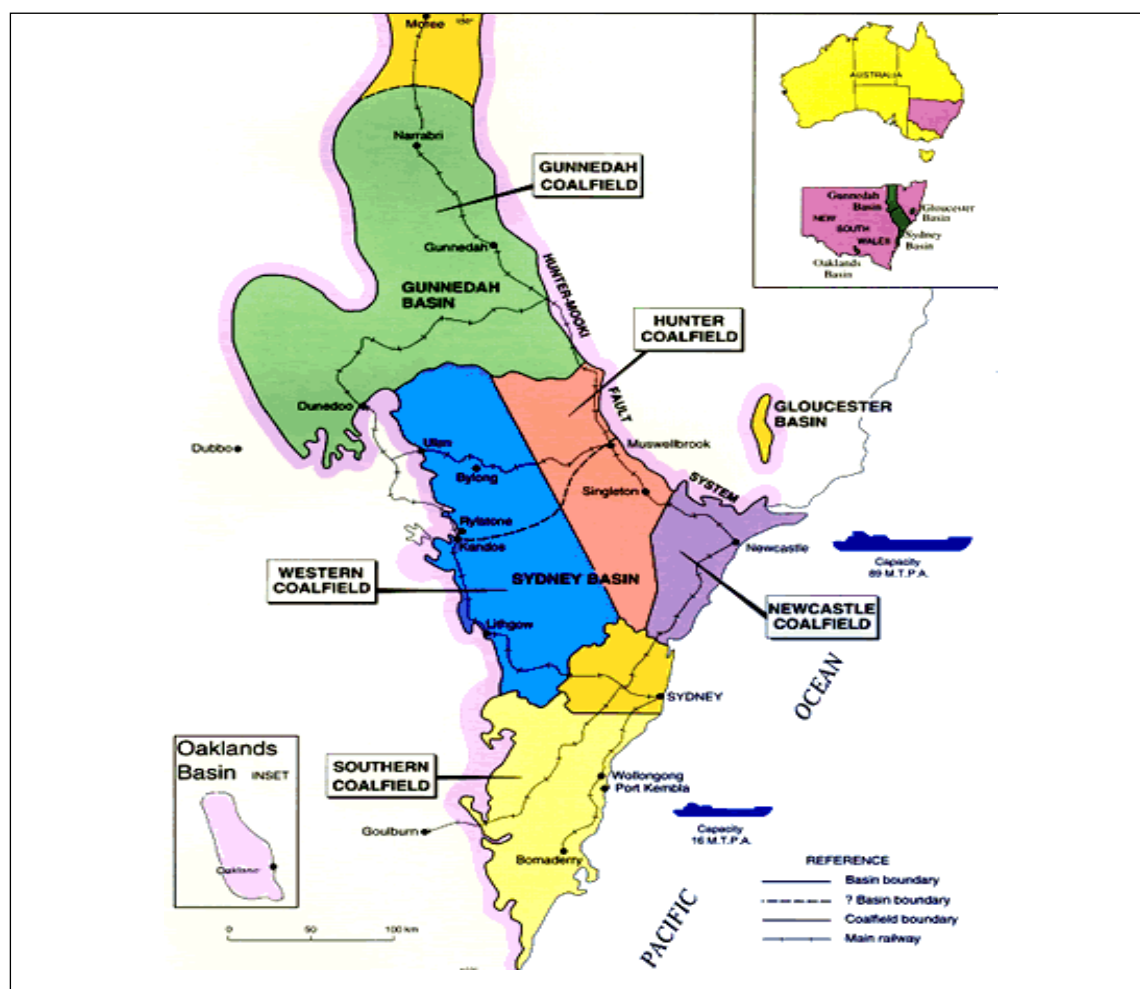
²⁰⁷ ABARE, "Australia Commodity Statistics, 2009," Table 244, p. 247.

²⁰⁸ Ibid, p. 1.

New steam coalfields that may be developed in NSW after 2015 will either be located in the Gunnedah Basin or the Hunter Valley. Coal from these new developments will be more expensive to deliver to export customers due to the longer distances from the new mine sites to the Port of Newcastle and the need to either construct new rail lines or expand existing rail lines.

Table 5 provides typical specifications for NSW export-grade steam coals by coalfield. Coals from the NSW coalfields are typically exported under the Newcastle brand, which has a gross calorific value of 6322 kcal/kg, gross, as received (gar) and 6000 kcal/kg, net, as received (nar). These coals are exported out of the Port of Newcastle, hence the Newcastle brand name.

Figure 26: Coal Basins, Fields and Export Ports in NSW



Source: Government of NSW, Department of Primary Industries.

Table 7: Quality Specification for Typical NSW Export-Grade Steam Coals

Coal Quality Parameter ↓	Coal Field →	Southern	Western	Hunter	Newcastle	Gunnedah
	Reporting Basis ↓					
GCV (kcal/kg)	GAD	6,750	6,600	6,810	6,760	7,050
GCV (kcal/kg)	GAR	6,390	6,220	6,360	6,330	6,515
Total Moisture (%)	AR	6.4	8.0	9.1	8.5	9.0
Inherent Moist (%)	AD	1.1	2.6	2.7	2.3	1.5
Ash (%)	AD	19.5	20.4	13.5	15.1	17.5
VM (%)	AD	20.8	28.7	32.7	30.6	26.8
TS (%)	AD	0.45	0.55	0.60	0.60	0.65
AFT (c)	Int. Deform. Red. Atmos.	1460	1460	1270	1380	1530
HGI (#)	n/a	64	45	50	52	65

Source: www.AustralianMinesAtlas.com

3.1.2 Queensland Coal Resources

As of December 2008, Queensland had in situ black coal EDR of 22 billion tonnes.²⁰⁹ Almost all of Queensland's coal reserves are located in the Bowen and Surat basins with small EDR quantities located in the Clarence-Moreton and Callide basins.²¹⁰ Queensland's coal resources range from high-quality coking coals to low-rank brown coals. However, its coal industry has been built around the high-quality coking coals that are located in the Bowen Basin. These coals, which command premium prices in export markets, are produced mostly from large open-cut mines in the Bowen Basin (Figure 27). However, export-quality black coal, especially steam coal resources, can be found throughout the state and in particular in the Surat and Galilee basins located inland from the Bowen Basin.

²⁰⁹ Ibid, p. 1 (39.2 bt x 0.56).

²¹⁰ [Geoscience Australia](#), Canberra, "Australia's Identified Mineral Resources, 2009," p. 1.

According to Geoscience Australia, approximately one-third of the remaining steam coal resources located in the Bowen Basin are amenable to open-cut mining.²¹¹ Any other steam coal mines developed in the Bowen Basin are likely to be underground longwall mines that will entail higher mining costs.

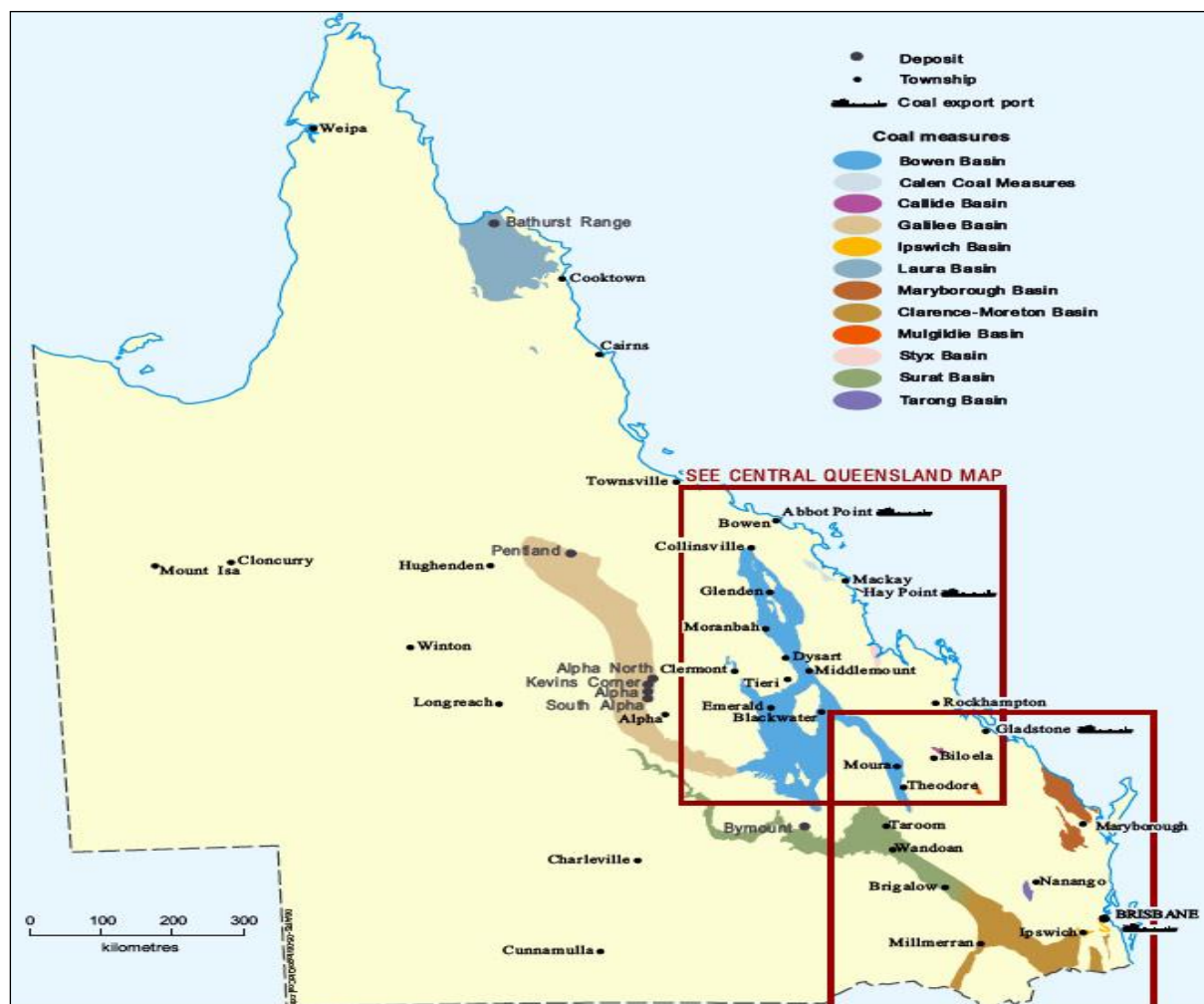
3.2 Expansion of Existing Steam Coal Mines

Both the NSW and Queensland coal mining industries have enjoyed a period of exceptional prosperity between 2004 and 2008 due to rising coal prices. Higher coal prices have also stimulated new coal exploration projects and investments in either new mines or expansions of existing mines. Table 6 summarizes the level of sustainable steam coal production from existing mines and new mines, each with a potential output of less than 10 mpta. The level of new output that may be generated from the sum of these coal mine expansion projects between 2010 and 2015 is estimated at 90 mtpa.²¹² It excludes production estimates for mines that will be producing only coking coal and also for large steam coal developments planned for the Galilee and Surat basins in Queensland and the Gunnedah Basin in NSW. These large planned steam coal developments are discussed later.

²¹¹ Queensland Government: Department of Mines and Energy “Queensland’s World-class Coals: mine Production and Developments, November 2007, p.1
(http://www.dme.qld.gov.au/zone_files/coal_files_pdf/wcc_nov_07.pdf)

²¹² A database showing the productive capacities of most steam coal mine expansions and new steam coal mines for NSW and Queensland, was prepared in 2009 for PESD by Michael Friederich, an independent coal geologist from Queensland. It contains information on those steam coal projects that have advanced to the stage of construction. The database excludes all developments for the Surat, Galilee, and Gunnedah basins and mines in other basins that produce only hard coking coal. The production forecast assumes that each announced project is economically feasible and will go forward.

Figure 27: Coalfields in Queensland



Source: www.AustralianMinesAtlas.com

Incremental expansions of existing steam coal mines will lead to very large increases in the aggregate amount of steam coal produced in NSW and Queensland over the next decade. However, over time, the mineable steam coal reserves of these competitive fields will be exhausted and an inevitable decline in steam coal production will occur if new fields are not developed.

For example, using current estimates of mineable reserves for each mine asset summarized in Table 6, and assuming that each mine produces at 80 percent of its rated capacity, the level of production capacity backed by mineable reserves will start to decline sometime between 2020 and 2025. Sometime between 2030 and 2040, if no new fields are brought into production, then sustainable capacity for production of steam coal from these mines is expected to drop

below the 2010 production capacity of mines that produce either only steam coal or a combination of steam and coking coal.

Table 8: Forecast of Increases in Steam Coal Mining Capacity Due to Expansion of Existing Mines in NSW and Queensland, 2010-2040

State	Mine type	2010	2015	2020	2025	2030	2040
Queensland	Open Cut	80.7	106.0	119.8	108.3	95.1	66.4
	Underground	0.9	1.2	1.2	1.2	1.2	1.1
	Subtotal	81.7	107.3	121.1	109.6	96.4	67.5
Newcastle	Open Cut	111.4	145.5	159.1	156.2	146.2	88.7
	Underground	52.3	80.9	79.4	60.8	50.8	40.9
	Subtotal	163.7	226.5	238.5	217.0	197.0	129.6
Both States	Open Cut	192.1	251.6	279.0	264.6	241.4	155.1
	Underground	53.2	82.2	80.6	62.0	52.0	42.0
	Total	245.4	333.7	359.6	326.6	293.4	197.1

Source: Summary of coal resource database prepared by Michael Friederich, consulting coal geologist, for this study, 2009.

This forecast does not preclude the possibility of additional discoveries adding to the reserve figures, especially in the form of new underground mines in NSW. But given the maturity of the existing coalfields and the level of exploration that has been accomplished for these fields, it is unlikely that additional discoveries and developments of open-cut mines will occur post-2025.

The conclusions offered here regarding the nature of production expansion have significant implications for not only future production costs but also export prices. The underground mine developments that do occur will have a higher cash costs than the open-cut mines they displace. It is expected that average, industry-wide cash costs for coal production will increase significantly between 2010 and 2025 as new underground and open-cut mines are brought into production.

3.3 Major New Coalfields Being Developed in Queensland

Sustaining a national production level of more than 300 mtpa of saleable steam coal after 2025 is likely to require the full development of the Galilee and Surat basins in Queensland and the Gunnedah Basin in NSW. Over the next two decades, steam coal will capture a larger share of Australia's black coal markets than it does today. The main reason for this shift will be the eventual depletion of the high-quality coking coal deposits of the Bowen Basin and their replacement with steam coals produced from within the Bowen Basin and Hunter Valley and from new open-cut mines located in the Surat and Galilee basins and the Gunnedah Basin in NSW.

3.3.1 Surat Basin

The Surat Basin lies to the south of the Bowen Basin and is reported to contain at least 4.0 billion tonnes of undeveloped, steam coal resources.²¹³ Most of the Surat Basin coals can be extracted using open-cut mining methods. The coals are viewed as attractive plays because of their moderate ash (10-12 percent) and low sulfur contents (0.6 percent). However, Surat Basin coals have one quality issue that may limit their sales in Asia, at least initially. The Surat Basin coals have relatively low HGIs that range between 32 and 35.²¹⁴ Most power plants in Asia have mills designed to take coals having an HGI of 45 or higher. If lower HGI coals are used in those plants, the mills may run out of grinding capacity and the plants' owners may need to derate the generating capacity of these plants.

Some Surat Basin mines, such as Kogan Creek and Wilkie Creek, are already in production, but most of the Surat Basin coal deposits still remain undeveloped. However, this is about to change over the next three to five years if two companies—Xstrata and Syntech Resources—bring their very large Surat Basin coal deposits into production. These two developments are expected to add 50 mtpa of new steam coal production by 2015 (Box 3.1).

3.3.2 Galilee Basin

The second area of interest within Queensland is the Galilee Basin, which is located in north-central Queensland, west of the Bowen Basin (Figure 28). The Galilee Basin is estimated to hold more than 10 billion tonnes of in situ JORC-compliant steam coal deposits. The areas of

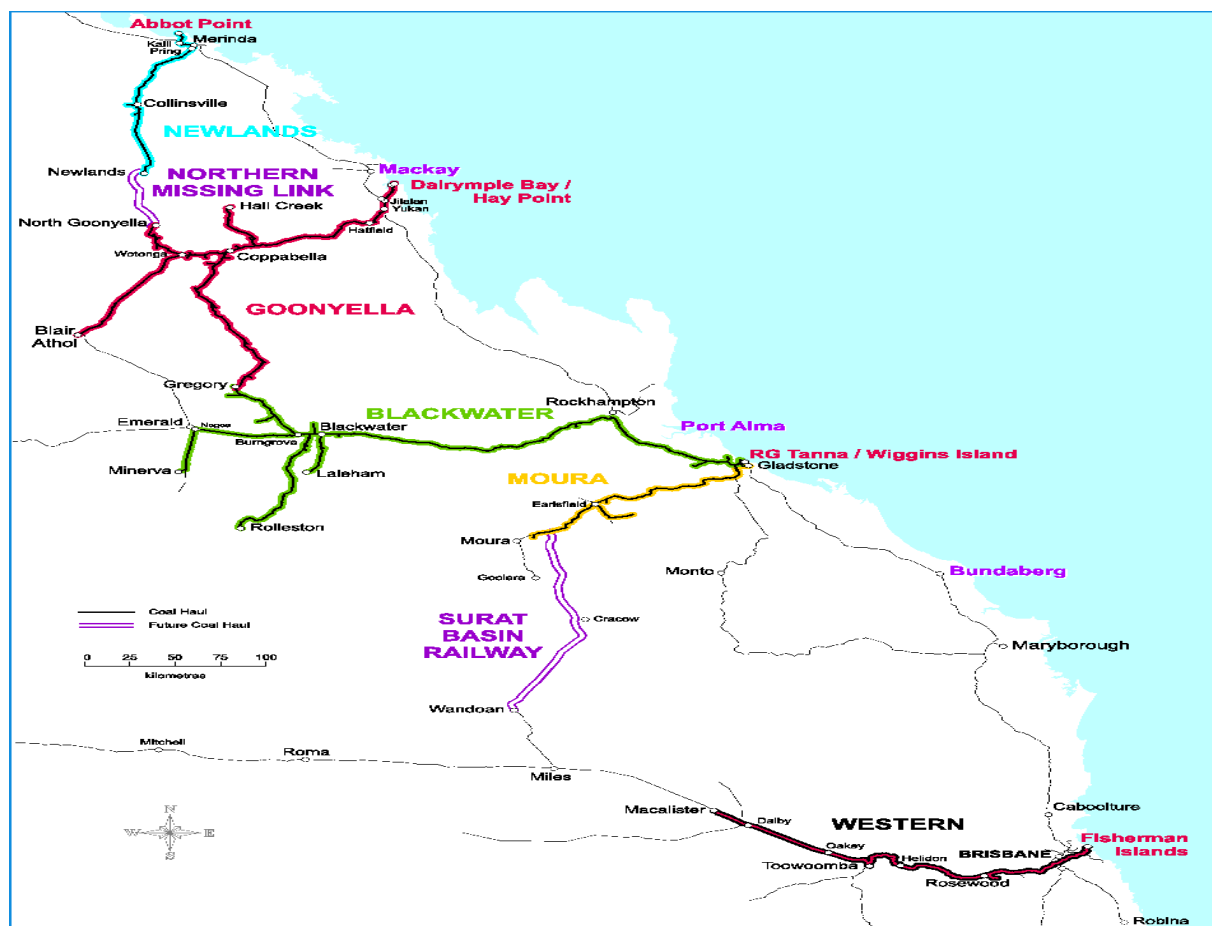
²¹³ Surat Basin Rail Joint Venture, "Rail Update Fact Sheet, November 2007 (www.suratbasinrail.com.au/files/SBR-fact-sheet-december07.pdf, Queensland Government)

²¹⁴ HGI, which is short for Hardgrove Grindability Index, is a measure of a coal's hardness or more precisely the difficulty that a power plant's coal mills will have in grinding it.

primary interest are those located in the eastern part of the Galilee Basin and referred to in the industry as the “Alpha deposits.” These coal resources are all steam coals.

The seams are shallow and the overburden can be removed with little or no blasting. The coals are relatively high in ash and will need to be washed before railing to export ports. The yield of saleable coal after washing is expected to range from 60 percent to 85 percent but the resulting coal quality should equal the quality of washed Surat Basin coals, except for HGI, which will be much higher for Galilee Basin coals (> 50 versus 32 to 35 for Surat Basin coals). A description of the most advanced new steam coal projects that will be developed in the Galilee Basin in Queensland are described in Box 3.2.

Figure 28: Railway-Port Connections from Existing and Planned Queensland Coal Mines



Source: Queensland Government, “Coal Transport Infrastructure in Queensland: Overview of Future Expansion,” updated September 2008 and available at www.transport.qld.gov.au.

Box 3.1: Surat Basin Projects

Xstrata-Wandoan Project: Xstrata plans to bring its Wandoan field and the related Surat Basin Rail project into commercial operation by 2014, the same time that the first stage of WICET, the new coal terminal at Wiggins Island within the Port of Gladstone, is also expected to be operating. Wandoan is conservatively estimated to have economically recoverable reserves of 1.2 bt of steam coal with a typical CV of 5900 kcal/kg and ash content of 8 percent to 10 percent. The coal will be sold after washing.²¹⁵

Initially, Xstrata was planning to develop a mine at Wandoan capable of producing 30 mtpa of raw coal over 30 years. However, subsequent exploration work has proved much larger reserves. According to a recent Xstrata news release, Wandoan reserves are now deemed to be sufficient to support a mining operation of 100 mtpa of run of mine steam coal over a 30-year period.

The full 100 mtpa mining capacity will be developed over the next decade as market conditions and rail and port infrastructure allow. As part of the Wandoan project, Xstrata will support the development of a new 210 km rail line, known as the Surat Basin railway project, which will be constructed between the mine at Wandoan up to the existing Moura-Gladstone line. Xstrata and two other companies are conducting the detailed feasibility study for the new rail project. The Wandoan coal project received its EIS approval from the government of Queensland in November 2010. The Surat Basin railway project is currently at the stage of final EIS review.

Syntech–Cameby Downs Project: In early 2009, Syntech Resources, which announced plans to develop its Cameby Downs steam coal project, estimates that the mine will cost \$250 million to develop with production commencing in 2010 at 1.4 mt of saleable coal. Syntech plans to quickly ramp up production to 20 mtpa of saleable coal by 2013 with the Port of Gladstone (Wiggins Island Coal Terminal) as the eventual export port. This project is expected to share the costs of developing the Surat Basin railway project with Xstrata.

²¹⁵ Details concerning the run-of-mine and washed coal specifications were not available for this draft of the paper.

Box 3.2: Galilee Basin Projects

Hancock Coal²¹⁶ and Waratah Coal are leading the development of the coal deposits Galilee Basin.²¹⁷ They have publicly announced plans to bring anywhere from 60 mtpa to 120 mtpa of new steam coal deposits into production between 2013 and 2015. In particular, Hancock and Waratah have developed two Galilee Basin projects—Alpha and Waratah—to the point where they have reached the EIS and bank feasibility study phases of development.

The Alpha and Kevins Corner coal projects, which are being developed by Hancock Coal, are located right on the far eastern edge of the Galilee Basin. These two deposits have been most extensively drilled and delineated according to JORC standards. As of December 2010, Hancock claims to have identified 7.9 billion tonnes of JORC-compliant resources (measured, indicated, and inferred), of which at least 2.4 billion tonnes are classified as measured and indicated resources. Hancock estimates that its coal after washing will have the following quality parameters:

HGIs - 50 and above

CVs - 5500 kcal/kg (gar) to 6900 kcal/kg

Sulfur - 0.4 percent to 0.8 percent

Ash - 8 percent to 14 percent.

Development of the Alpha and Kevins Corner resources will require the construction of a new railway line between these two mine sites and a new coal terminal with a coal handling capacity of 60 mtpa within the existing Port of Abbot Point. This coal handling capacity is in addition to previously announced plans to expand Abbot Point's coal handling capacity to 110 mtpa by 2020. The plan is to construct two mines and supporting rail and port infrastructure that can support an eventual ROM production of 60-80 mtpa.

The Waratah project is being developed by Waratah Coal, which holds steam coal

²¹⁶ Hancock Coal Pty. Ltd., a subsidiary of Hancock Prospecting Pty. Ltd.

²¹⁷ Waratah Coal was recently acquired by Clive Palmer and the asset names and other details are likely to change over the next year. He plans to hold the asset through his Hong Kong-based company called Resourcehouse and to raise A\$2 billion to A\$3 billion in an IPO for Resourcehouse to finance the development of the Waratah Coal project and its related infrastructure.

tenements that are contiguous to Hancock's Alpha and Kevins Corner deposits. Waratah's tenements are considered an extension of Hancock's two deposits. Less information is available on the Waratah tenements and the company's development plans than is available for the Hancock projects. Waratah Coal plans to develop a mine with a ROM production capacity of 40 mtpa that will generate saleable steam coal production after washing of 30 mtpa. Waratah will either build its own 290 km rail link to Abbot Point or build it in cooperation with Hancock Coal. The "go-it-alone" cost of the railroad is estimated at A\$2.1 billion (2008 prices) while the mine and port are estimated to cost A\$3.18 billion and A\$1.27 billion, respectively.

Table 7 provides a summary of the new mining projects that are at advanced stages of development. Other less developed projects, such as the Adani and Bandanna projects in the Galilee Basin, are likely to follow. Additional tenements are being considered for development in the Galilee and Surat basins, not only for coal production but also for production of CBM and for UCG projects.

Table 9: New Mining Projects in the Galilee and Surat Basins at an Advanced Stage of Development (as of June 2010)

Developer	Basin	Deposit	2010 Resource Estimate ^Ω (billion tonnes)	First Shipment (years)	Export Capacity (mtpa)	Distance to Port (km)	Total Capital (billion AUS\$)
Hancock Coal	Galilee	Alpha Coal	3.6	2013	30	495	7.5
Hancock Coal	Galilee	Kevin Comer	3.4	2013	30	495	9.0
Waratah Coal	Galilee	Waratah	4.3	2013	40	495	5.3
Xstrata	Surat	Wandoan	2.7	Late 2014	22	380	6.0
Syntech	Surat	Cameby Downs	1.4	2010	12-15	430	n/a
Ω Hancock Coal and Wandoan resource estimates include Measured, Indicated and Inferred only; Xstrata also estimated that it has 400 mt of Marketable Reserves (Proved and Probable).							

Sources: Hancock Coal (www.hancockcoal.com.au/go/current-projects/kevin-s-corner); Waratah Coal (www.dip.qld.gov.au/projects/mining-and-mineral-processing/coal/waratah-galilee-coal-project.html); Xstrata (www.wandoancoalproject.com.au/mediacentre_protocols.cfm); and Syntech (www.syntechresources.com.au).

3.4 Rail and Port Infrastructure Constraints

Rail and port infrastructure capacity shortages have constrained Australia's black coal exports off and on since 1997. Their occurrence, although only emerging as a serious issue in 1997, were given prominent mention in the report of Productivity Commission on Australia's black coal industry.²¹⁸ However, they have become a sustained and chronic issue since 2006.

Delays in loading ships at the major ports of Newcastle, Gladstone, and Hay Point have, over the past five years, created cost and reputational issues for Australia's black coal industry. With regard to costs, miners have been confronted with substantial demurrage charges, which in 1997 were estimated for the Port of Newcastle at A\$ 100 million. The impact of these demurrage charges was to effectively double Newcastle port charges from A\$2.80 per tonne to A\$5.40 per tonne in 1997. From a reputation standpoint, the word quickly spreads that coal shipments from Australia will be subject to long and variable delays with miners occasionally

²¹⁸ Productivity Commission, 1998, "The Australian Black Coal Industry," Inquiry Report, AusInfo, Canberra.

using such delays to excuse themselves from their contract obligations. During the volatile price phase, the issue of port and rail capacity constraints reached a critical point with vessel queues at the Port of Newcastle ranging from 70 to 80 vessels over extended periods of time in 2007 and 2008.

More recently, the “port of Newcastle disease” appears to have spread to Hay Point’s Dalrymple Bay Coal Terminal (DBCT). For the month of November 2010, DBCT suffered an average vessel queue of 30 vessels and an average turnaround per vessel of 25 days. The Kooragang/Carrington Coal Terminals (KCCT) at the Port of Newcastle had a much longer vessel queue (45 vessels) but a much shorter turnaround time for each vessel (14 days).²¹⁹

To put these numbers in perspective, a well-managed port with adequate capacity should take no more than four days to turnaround a Panamax vessel and six days to turnaround a Cape-size vessel. The four- to six-day allowance includes the time required to berth the vessel, load the coal into the holds of the vessels, and trim the vessel for sailing. At 2010’s depressed vessel charter rates it cost only \$20,000 per day to charter a Panamax vessel with a 70,000 tonne cargo-carrying capacity and \$25,000 per day to charter a Cape-size vessel with a cargo carrying capacity of 160,000 tonnes. The demurrage charge for the Panamax vessel will amount to US \$200,000 or US \$2.86 per tonne while the demurrage charge for the Cape will equal US\$1.56 per tonne at KCCT. In the case of DBCT, the demurrage charges will be much higher at \$5.10 per tonne for a Panamax vessel and \$2.78 per tonne for a Cape-size vessel.

Despite these unresolved infrastructure constraints, Australia still managed to increase its black coal exports by a respectable 4.7 percent per year between 2006 and 2009. The real question is what could have been achieved if adequate rail and port infrastructure was available during those years.²²⁰

3.4.1 Queensland Ports and Rail Networks

Figure 24 shows the locations of the four main coal ports of Queensland—Abbot Point, Dalrymple Bay/Hay Point, Gladstone, and Brisbane—and their related rail systems. The government of Queensland owns the four coal ports through three government corporations:

²¹⁹ Energy Publishing, “Coal Chain Australia,” Issue 0014, December 2010, pp. 4-8.

²²⁰ During 2007-2008, the coal supply problems caused by the chronic transport constraints were exacerbated by a severe storm in June 2007 in the Hunter Valley, which reduced expected black coal output by more than 3 million tonnes.

- The Port Corporation of Queensland, which owns and operates the ports of Abbot Point and Hay Point
- The Gladstone Ports Corporation, which owns the Port of Gladstone
- The Port of Brisbane

The government of Queensland, in 2008, publicized its plans for expanding the capacities of a number of its coal ports and their related rail systems over the next decade, which, if realized, would result in the expansion of the nameplate coal handling capacity of Queensland's ports from 263 mtpa in 2008 to 392 mtpa by 2020.²²¹ Moreover, these plans do not consider the most recent projects announced by Hancock Coal, Waratah Coal and Adani to build separate rail lines and coal terminals at Abbot Point and elsewhere that might lead to another 100 mtpa of new nameplate port capacity being added by 2020. Significant expansion projects as announced by the government of Queensland for each coal handling port, including very recent announcements for Abbot Point, are described below.

Port of Abbot Point: The Port of Abbot Point is owned and operated by the North Queensland Ports Corporation Ltd. (NQPC), a government-owned corporation. Abbot Point has a single coal terminal with a nameplate capacity of 25 mtpa, which is owned and operated by Xstrata through its subsidiary, Abbot Point Bulk Coal Pty. Ltd. (APBC). Xstrata also owns the Newland and Collinsville mines, which export 100 percent of their saleable production through the Abbot Point coal terminal.

The Abbot Point coal terminal will be expanded to 50 mtpa by 2012. The expansion is being completed in three stages at an estimated cost of A\$690 million (2007A\$). Once it completes the 50 mtpa expansion project, the government of Queensland will start the implementation of its X110 expansion project, which will involve expanding the coal handling capacity of the Port of Abbot Point to 110 mtpa and constructing the necessary rail lines, primarily the northern missing link rail line, to carry coal from coal mines in the central Bowen Basin to Abbot Point. Finally, both BHP Billiton and Hancock Coal have been awarded preferred developer status to develop their own coal handling facilities at Abbot Point plus related rail

²²¹ In 2008, the Ministry of Industry issued a comprehensive report outlining its plans for expanding port and rail infrastructure to support the development of the Surat and Galilee basins and allow increased production from the Bowen Basin. This report, which is dated September 2008, is available from www.transport.qld.gov.au.

lines, which may result in an additional 100 mtpa of nameplate coal handling capacity being added to Abbot Point beyond the X110 planned expansion. A recent presentation by the government of Queensland suggests that Abbot Point might reach a total coal handling capacity of 180 mtpa by 2020.²²²

Port of Gladstone: The Port of Gladstone is owned and operated by the Gladstone Ports Corporation (GPC), a government-owned corporation previously known as the Central Queensland Port Authority. GPC also manages the port terminal at Alma. Coal is the largest commodity shipped out of Gladstone, which has two coal handling terminals:

- Barney Point Coal Terminal with a throughput capacity of 7 mtpa
- RG Tanna Coal Terminal with a 2008 throughput capacity of 72 mtpa

The capacity of the Barney Point terminal will remain fixed at 7 mtpa until 2015 when it will be retired and its capacity handled by the new Wiggins Island Terminal. RG Tanna will remain fixed at 72 mtpa and will continue in operation at that capacity until at least 2030. The RG Tanna Coal Terminal is shown on the far right of Figure 29.

To meet industry needs for additional coal handling capacity, GPC is supporting the development of a new coal terminal, known as the Wiggins Island Coal Export Terminal (WICET), within the Port of Gladstone. WICET will be operational by 2013 with an initial capacity of 25 mtpa. In 2008, a consortium of 16 coal companies was awarded “preferred developer status” by the government of Queensland to develop WICET.²²³ State and Australian government environmental planning approvals for the terminal were obtained in the same year. The plan is for the WICET consortium to build, own, and finance the new terminal, under a long-term lease, with Gladstone Ports Corporation as the operator.

²²² Fish, Brad, “The Port of Abbot Point Multi Cargo Facility Project,” Presentation to the Major Projects Conference – October 19, 2010 (available online: <http://www.dip.qld.gov.au/resources/major-projects/presentations/mpc10/brad-fish.pdf>).

²²³ Originally, there were 16 members of the WICET consortium: Anglo Coal Australia, Aquila Resources, BHP Billiton, BHP Billiton Mitsubishi Alliance (BMA), Caledon Coal, Cockatoo Coal, Felix Resources, Jellinbah Resources, Macarthur Coal, Northern Energy Corporation, Qcoal, Rio Tinto Coal Australia, Syntech Resources, Vale Australia, Wesfarmers Curragh, and Xstrata Coal Queensland. As of June 2009, the number of shareholders in WICET has decreased to 12 as a few companies had to drop out for financial reasons.

Figure 29: Coal Terminals at Port of Gladstone



Source: Port of Gladstone website (www.gpc.co.au).

The GPC is proposing to expand WICET's capacity to 70 mtpa after 2015. Concurrent rail extensions will include the Surat Basin railway project, a 230-kilometer rail line that will connect the Surat Basin coalfields with the existing Moura-Gladstone line. The existing line will be upgraded to support the development of WICET. The cost of WICET is estimated at A\$4 billion and the related rail expansions, including the Surat Basin railroad, at A\$1 billion. In October 2010, the WICET consortium announced that the commissioning date for the first stage of WICET (27 mtpa) would occur in 2014, two years later than originally planned. Before financial close can be announced, eight coal producers—Aquila Resources, Bandanna Energy, Caledon Resources, Cockatoo Coal, Northern Energy Corp., Wesfarmers Curragh, Xstrata Coal, and Yancoal—must sign legally binding take-or-pay agreements with WICET. The delay in commissioning the first stage of WICET until 2014 will also delay the start of production for Xstrata's Wandoan project and the full expansion of the Syntech Resources Cameby Downs project.²²⁴

²²⁴ (www.gladstoneobserver.com.au/story/2010/10/01/eight-sign-on-for-wicet-wiggins-island-coal).

Port of Hay Point: The Port of Hay Point is owned and operated by the North Queensland Port Commission (NQPC). It consists of two separate coal terminals:

- **Hay Point Coal Terminal (HPCT)**, which is owned and operated by the BHP Billiton-Mitsubishi Alliance (BMA) and handles only coking coals, has a nameplate capacity of 44 mtpa. In 2009, HPCT exported 34.7 mt of coking coal down from 36.9 mt in 2007/2008. It is now considering expansion projects to bring the potential export capacity to 55 mtpa by 2012.
- **Dalrymple Bay Coal Terminal (DBCT)**, which is leased by Babcock & Brown Infrastructure (BBI) from the Port Corporation of Queensland (PCQ) (renamed as NQPC) and is currently rated at 85 mtpa nameplate capacity. The coal terminal is available to all coal suppliers. It handles both steam and coking coals. In 2009, DBCT handled 54.2 mt of coal exports, a significant improvement over FY 2007/2008 when DBCT exported only 43.6 mt of steam and coking coal. However, given its very high nameplate capacity of 85 mtpa, it is surprising how low DBCT's annual throughput has been.

3.4.2 NSW Ports and Rail Networks

NSW is limited to one very large coal port—the Port of Newcastle. This limitation is partly due to the topography of the state, which has a coastal mountain range that separates the coal mines of the Hunter Valley from the coast until Newcastle. Port Kembla, which handles both steam and coking coals, provides some “back-up” port capacity. But it has a very limited nameplate capacity of 18 mtpa and does not have room for further expansion.

Port of Newcastle: The Port of Newcastle is government owned through the Newcastle Port Corporation. Government oversight is provided by the Ministry for Ports and Waterways, the Ministry of Finance, and the Treasurer's Office. Within the Port of Newcastle, there are two coal terminals—the Kooragang Coal Terminal with a 2010 nameplate capacity of 77 mtpa and the Carrington Coal Terminal with a 2010 nameplate capacity of 25 mtpa. (Figure 30) These two coal terminals, which are operated by Port Waratah Coal Services, Pty. Ltd. (PWCS) under contract to the Newcastle Port Corporation, handled 93.0 mt of black coal exports in 2009. The government of NSW plans to increase the port's coal handling capacity by adding a third coal terminal known as the Newcastle Coal Infrastructure Group (NCIG) terminal. The first stage of the NCIG terminal achieved commercial operation in late 2010 with an initial coal handling capacity of 30 mtpa. By 2015, NCIG is expected to reach a total coal handling capacity of 66 mtpa and the Port of Newcastle will have a total nameplate capacity of 192

mtpa. The total cost of the NCIG terminal is estimated at A\$1 billion including construction contingencies. NCIG will be owned by six coal producers: BHP Billiton, Centennial Coal, Donaldson Coal, Felix Resources, Peabody, and Whitehaven Coal.

Figure 30: Port of Newcastle's Kooragang and Carrington Coal Terminals



Source: Port of Newcastle website.

Port Kembla: NSW's only other significant coal handling port is Port Kembla with a nameplate capacity of 18 mtpa. Port Kembla's coal handling capacity is expected to remain fixed at that level through 2020. In 2009, Port Kembla processed 14.4 mtpa of mainly coking coals.

3.4.3 Continuation of Chronic Port and Rail Shortages

The government of Queensland put forward a plan in 2008 to expand its port and rail capacities from 238 mtpa in 2008 to 392 mtpa by 2020. (Table 8) The government of NSW similarly put forward a plan to expand the Port of Newcastle's coal handling capability from 102 mtpa in 2008 to 192 mtpa in 2020. Once the new terminals at Abbot Point, Newcastle, and Gladstone

are completed, the total nameplate coal handling capacity of the ports of Queensland and Newcastle will increase from 263 mtpa by the end of 2008 to 392 mtpa, an increase of almost 50 percent.

The coal ports located in Queensland and NSW had for all of 2010 a capacity utilization factor of 73 percent. If these ports could, on average, achieve an 80 percent capacity utilization factor, total black coal exports could reach 480 million tonnes by 2020, up from 261 mt in 2008. Assuming that the current split between coking coal and steam coal exports continues through 2020, steam coal exports could increase from 120 mtpa in 2008 to 216 mtpa without incurring any port or rail constraints. Figure 26 shows the existing rail network with planned extensions called the Northern Missing Link and the Surat Basin railways.

These expansion plans do not take into account the potential development of the Hancock and Waratah projects within the Galilee Basin, which will add an additional 60 mtpa to 100 mtpa of new steam coal production capacity over the next decade. Steam coal is therefore about to become a bigger share of Australia's black coal exports over the next decade due to stagnant demand for coking coal and expected moderate increases in steam coal to fuel new power plants in Korea, Taiwan, and China.

However, the budget deficit problems of the Queensland government and the regulatory uncertainty caused by the previous Commonwealth government led by Kevin Rudd have created doubts about the timings for most new projects. During his tenure as PM, Rudd attempted to pass into law a CO₂ cap-and-trade program and a resource super profits tax (RSPT), which created investor uncertainty and delayed a number of important rail and port expansion projects, especially the Surat Basin railway project and the Northern Missing Link railway project. Any prolonged delay in the Northern Missing Link rail project will also lead to a delay in the project to expand the Abbot Point Coal Terminal from 50 mt to 110 mt. Moreover, delays with these two projects will cause delays in developing new coal mines in the Galilee Basin and the northern Bowen Basin. If the Northern Missing Link project and/or the Surat Basin project are delayed for an extended period of time, the delay has also affected the commercial operation date for the new Wiggins Island Coal Terminal that is planned for the Port of Gladstone.

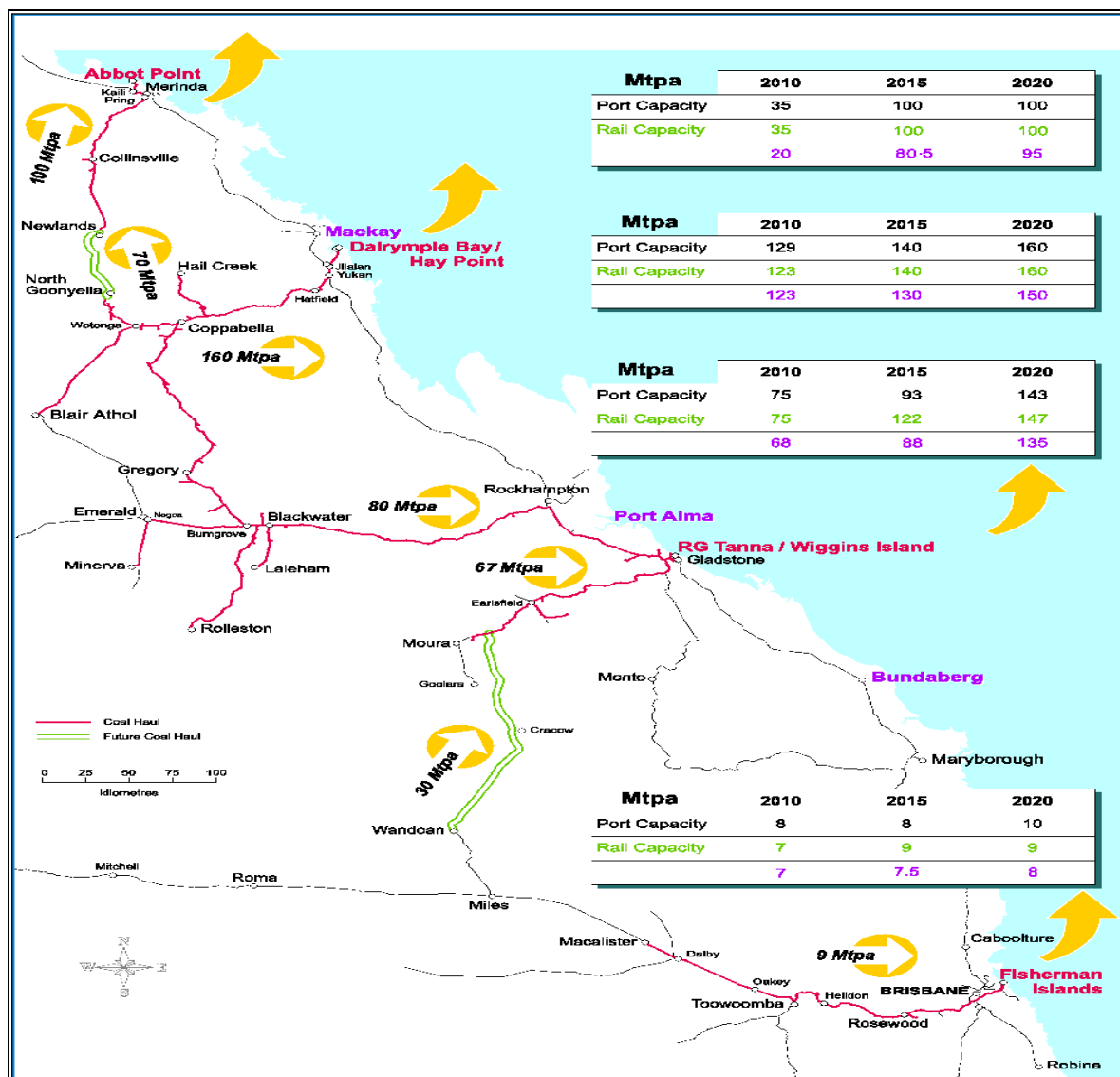
In June 2010, the WICET consortium announced a delay of one year for WICET, until 2014, largely due to the RSPT and other factors.²²⁵ As a result of the delay in WICET, the Surat rail project was delayed until 2014 with spill-over effects on the timing for Syntech Resources' Cameby Downs project. In short, additional steam coal supplies of about 100 mtpa will be two years late in reaching the market due to the investor uncertainty created by the policies of Kevin Rudd during his brief tenure as prime minister of Australia.

On the other hand, projects to expand the capacity of the port of Newcastle—and in particular, the project by the Newcastle Coal Infrastructure Group (NCIG) to build a second coal terminal on Kooragang Island with an eventual capacity of 60 mtpa—are on schedule. The first stage of the NCIG terminal (30 mtpa) was commissioned in late 2010 and the second stage (36 mt) has a planned commissioning date in mid-2012.

Figure 31 and Table 8 provide the 2008 port expansion plans for Queensland and NSW and the rail expansion plans of Queensland Rail up to 2020. They have not been updated to reflect delays announced during 2009 and 2010 by the Queensland government and Xstrata.

²²⁵ Energy Publishing Ltd., "Coal Chain Australia: Surat Rail frozen in tax debate, Wiggins delayed," Issue 0008 June 2010, pp. 1-2.

Figure 31: Queensland's Planned Rail and Port Capacity Expansions 2010 to 2020



Source: Queensland Government, "Coal Transport Infrastructure in Queensland: Overview of Future Expansion," September 2008.

**Table 10: Nameplate Capacity Forecasts for Major Coal Handling Terminals at Ports
Located in NSW and Queensland**

Port/Coal Terminal	Location	Nameplate Capacity (mtpa)					
		2006	2008	2010	2012	2015	2020
Newcastle	NSW						
1. Kooragang Coal Terminal		64.0	77.0	91.0	101.0	101.0	101.0
2. Carrington Coal Terminal		25.0	25.0	25.0	25.0	25.0	25.0
3. NCIG Coal Terminal Planned)		0.0	0.0	30.0	45.0	66.0	66.0
Sub Total		89.0	102.0	146.0	171.0	192.0	192.0
Port Kembla	NSW	16.0	16.0	16.0	16.0	16.0	16.0
NSW Total		105.0	118.0	162.0	187.0	208.0	208.0
Gladstone	Queensland						
1. RG Tanna Coal Terminal		51.0	72.0	72.0	72.0	72.0	72.0
2. Barney Point Coal Terminal		7.0	7.0	7.0	7.0	0.0	0.0
3. Wiggins Island (Planned)		0.0	0.0	0.0	0.0	25.0	70.0
Sub Total		58.0	79.0	79.0	79.0	97.0	142.0
Hay Point	Queensland						
1. Dalrymple Bay Coal Terminal		55.7	85.0	85.0	85.0	85.0	85.0
2. Hay Point Coal Terminal		40.0	44.0	44.0	55.0	55.0	55.0
Sub Total		95.7	129.0	129.0	140.0	140.0	140.0
Abbot Point	Queensland	15.0	25.0	50.0	80.0	100.0	100.0
Brisbane	Queensland	5.0	5.0	5.0	5.0	8.0	10.0
Queensland Total		173.7	238.0	263.0	304.0	345.0	392.0
TOTAL		278.7	356.0	425.0	491.0	553.0	600.0

Source: Queensland Government, “Coal Transport Infrastructure in Queensland: Overview of Future Expansion,” September 2008 (www.transport.qld.gov.au). (2006-2008 figures actual nameplate capacities, 2010-2020 figures are government forecasts)

3.5 Regulatory Issues

Between January 2008 and June 2010, the Commonwealth government, led by then Prime Minister Kevin Rudd, proposed sweeping changes to environmental rules and regulations and natural resources taxes—changes that generated political controversy and a fair amount of uncertainty in Australia’s coal mining and power industries. Due to his advocacy of these controversial issues and, in the minds of many, his non-consultative style of governing, Rudd was removed from power by his own party in June 2010. In his wake, he left behind two proposals—a carbon pollution reduction scheme (CPRS) and a resources super profits tax (RSPT)—subsequently restructured and renamed mineral resources rent tax (MRRT), which continues to generate serious concern within the coal mining industry.

3.5.1 Australia’s CPRS

The CPRS was borne out of a study prepared by Professor Ross Garnaut, one of Australia’s most distinguished economists.²²⁶ Garnaut issued the study in April 2008. It provided the rationales and principles upon which the government’s CPRS proposal was later structured. In particular, Garnaut proposed that Australia play its part in mitigating the impacts of climate change by passing into law a scheme for implementing a cap-and-trade CO₂ emissions reduction program based on the following principles:

- The UNFCCC²²⁷ definitions of greenhouse gases (CO₂ and five other greenhouse gases) and the methodology adopted by the UNFCCC to convert those different gases into CO₂ equivalent values (CO_{2e}) should be used for determining the amount of CO₂ emitted by a polluter.²²⁸
- The year 2000 should be adopted as Australia’s base year for assessing any targeted reductions in CO_{2e} emissions.
- The government should set CO_{2e} reduction targets equal to 20 percent of Australia’s 2000 CO_{2e} emission levels by 2020 and a 90 percent reduction by 2050 based on other

²²⁶ The Garnaut Climate Change Review: Final Report (available online at www.garnautreview.org.au).

²²⁷ UNFCCC stands for the United Nations Framework Convention on Climate Change.

²²⁸ The cap-and-trade concept was first proposed during the late 1960s as a practical emissions abatement method by the U.S. National Air Pollution Control Administration (NAPCA), the predecessor to the United States Environmental Protection Agency’s Office of Air and Radiation. At that time, NAPCA completed extensive computer simulation exercises, which showed that a “cap-and-trade” approach to pollution abatement was by far the least-cost solution for reducing emissions. The concept was not applied until 1990, when it was used for reducing SO₂ emission as part of the Acid Rain Program of the 1990 Clean Air Act. The SO₂ cap-and-trade system reportedly led to a 50 percent reduction in the 1987 level of SO₂ emissions by 2007.

polluting nations agreeing to proportionate reductions in their CO_{2e} emissions such that global CO_{2e} levels would be held at 450 ppm.

Relying heavily on the Garnaut report and his follow-on advice, the newly elected Rudd government, in early 2008, prepared a green paper, which spelled out the principles and mechanics of the proposed CPRS.²²⁹ The green paper was submitted to the public for its comments in July 2008. Based on extensive public inputs and government analysis of those inputs, a CPRS white paper was prepared and issued in December 2008.

The white paper was issued in two volumes and titled “Carbon Pollution Reduction Scheme: Australia’s Low Pollution Future.”²³⁰ It was comprehensive, logically organized, professionally edited, and insightful. Most importantly, it addressed significant issues raised by the public during the green paper consultation period in a direct and clear manner.²³¹ The white paper contained the following key components:

- Baseline year of 2000, for setting carbon emissions reductions
- Start date of July 2010, for CPRS
- Exempted sector: agriculture
- Affected entities: 1,000 (accounting for 75 percent of CO_{2e} emissions)
- Targeted reduction by 2020 (in year 2000 baseline emissions)
 - (a) 5 percent (as an unconditional commitment, independent of other country’s CO_{2e} reduction commitments)
 - (b) 15 percent (if a global agreement is reached for which all major economies commit to substantially restrain their CO_{2e} emissions and all developed countries accept binding CO_{2e} reduction targets equal to Australia’s)
- Long-term (2050) reduction target, 60 percent of 2000 CO_{2e} emissions
- Starting CO_{2e} permit price, A\$40/tonne

²²⁹ In Australia, a green paper is a national government report that contains a first proposal for a change in law without any commitment to action. It is a “first call for public inputs” and the first step taken before initiating a significant change in law. Green papers may result in the production of a white paper, which is an official statement of policy by the Australian government. It derived its name due to the historical fact that such papers were originally bound in white paper. The green paper supporting the CPRS can be found at www.climatechange.gov.au/~media/publications/green-paper/greenpaper.ashx.

²³⁰ The white paper for the CPRS can be found at www.climatechange.gov.au/publications/cprs/white-paper/cprs-whitepaper.aspx.

Once a white paper has been approved by the Cabinet, the next step in the Australian legislative process is to prepare “exposure draft legislation” and submit the draft bill to either the House of Representatives or the Senate to be considered for passing as an act of Parliament. The CPRS exposure legislation was a package of six related bills of which the Carbon Pollution Reduction Scheme 2009 was the main bill.

Draft bills are typically sent first to the House of Representatives, which is where most of the ministers reside. In the case of the CPRS draft bill, Senator Wong, despite being a senator, decided to have the bill originate in the House of Representatives, where it was strongly supported. The draft CPRS legislation was introduced into the House and read for the first time on May 14, 2009.²³² The House of Representatives completed the necessary three readings of the revised CPRS bill on June 4, 2009.

Recognizing that the CPRS legislation would face stiff opposition in the Senate, Rudd decided to submit to the Senate a “gutted” version of the bill that had just passed the House. The revised CPRS legislation contained the following concessions:

- The start date for the CPRS was delayed until July 2012.
- Polluters were allowed free issuance of 85 percent of all required carbon permits.
- The price of all other permits was set at a very low price of A\$10 per tonne during the first year of the CPRS.²³³

But the Senate remained unmoved by Rudd’s many concessions. The draft legislation was submitted to the Senate for its consideration on June 15, 2009, but it failed to pass the necessary three readings and was rejected in August 2009. The opposition senators focused the debate on CPRS around one key point—Australia should not unilaterally commit to a CO₂ cap-and-trade scheme before other far larger polluters, such as the United States, Japan, Korea, Taiwan, and China, agreed to a proportional reduction in their CO_{2e} emissions through a binding international agreement. In their view, consideration of the CPRS in the Australian

²³² Bills are not deemed approved by either of the two houses until the bill has gone through three readings. The first reading simply introduces the bill and reads it into the record. The second reading involves the debate of policy and principles and the third reading involves debating the details of the bill. Once it passes the third reading, the bill is typically passed from the originating house to the second house.

²³³ Australian Government Department of Climate Change “Summary: Key Changes to the Carbon Pollution Reduction Scheme Legislation,” May 2009.

Senate should be delayed until after the United Nations Climate Change Conference in Copenhagen.²³⁴

Australia's coal mining industry opposed the revised draft CPRS legislation for more specific reasons. First, industry representatives were upset at being ruled ineligible for transitional support under the emission-intensive trade-exposed sectors (EITES) program. They claimed that the government's rule for determining eligibility—based on CO_{2e} emissions per \$ of revenue and CO_{2e} emissions per \$ value added over two years (2007 and 2008)—arbitrarily resulted in the coal industry being declared ineligible. Coal industry representatives argued if a longer period of time, say four to five years was used, the coal industry would have qualified for EITES's funding.

Second, and more importantly, the government decided to include fugitive methane emissions from both open-cut and underground coal mines as one of the coal industry's CO_{2e} emission obligations. The coal industry objected and argued that methodologies for making such estimates are incomplete, if not fatally flawed. It argued further that any attempt to impose such a liability on Australia's coal producers was both inequitable and would lead to an inefficient market solution.

Finally, the coal industry stated that no other government in the world was presently considering fugitive methane emissions from coal mines as a cap-and-trade obligation due to the difficulty in measuring such emissions from open-cut mines. Industry respondents recommended that this provision of the CPRS be dropped until an international agreement could be reached on how to deal with fugitive methane emissions from all coal mines—both underground and open-cut mines—as a CPRS obligation. The coal industry was also frustrated by what it felt was favored treatment for the LNG and pipeline gas industries.

A revised CPRS bill, known as the Carbon Pollution Reduction Scheme Bill 2009 (No. 2), was introduced in the Australian House of Representatives on October 22, 2009, which approved it for sending to the Senate on November 16, 2009. The following day, November 17, 2009,

²³⁴ Participants to the UN's Copenhagen Conference were expected to agree on a successor to the Kyoto Protocol and CO_{2e} emission reduction provisions that would commit all developed countries to reduce their CO_{2e} emissions in 2020 and 2050 below some baseline levels and in the case of developing countries agree to a binding program for reducing the growth of their emissions. The conference was held between December 7 and December 19, 2009, in Copenhagen but failed to meet its lofty goals. A subsequent climate change conference organized under the auspices of the UN's COP15 organization was held in Cancun, Mexico, between November 29 and December 10, 2010. Only minor agreements were reached at that conference.

CPRS No. 2 was introduced into the Senate but was rejected on December 2, 2009. In early 2010, the Rudd government tried a third time to pass the CPRS into law with the introduction of a revised bill, known as the Carbon Pollution Reduction Scheme Bill 2010. It passed through the House on February 11, 2010 and was introduced into the Senate on February 22, 2010, where it was once again voted down.

As a result of three failed attempts, Rudd decided to drop any further attempts to pass the CPRS into law until 2013. He blamed the failure of the COP15 Copenhagen Climate Change Conference and the lack of a broad international commitment to reduce emissions of GHGs as the reason. In fact, Rudd probably realized that he would never get the CPRS passed in the Senate and was simply looking for a face-saving way to put it on the back burner.

Because the Australian Senate rejected the CPRS bill twice, under the Australian Constitution, the government could have, at that point in time, dissolved Parliament and called a general election. In March 2010, Rudd proceeded to call a general election for October 2010 but, ironically, not based on the Senate's multiple rejection of the CPRS legislation but due to the two-time rejection of a health care reform bill. But Rudd did not stay in power long enough to contest the 2010 general election. In June 2010, as a result of Rudd's attempt to impose a very unpopular resource super profits tax (discussed next), Rudd was voted out as PM by his own party and replaced by veteran politician, Julia Gillard.

The CPRS remained on hold until 21 December 2010, when an ad hoc committee known as the Multi-Party Climate Change Committee (MPCCC), consisting of members of the ruling Labour Party, the Greens and two independent parliamentarians, released a proposal to implement a fixed carbon tax by July 2012.²³⁵ However, it was not until 24 February 2011 that the Prime Minister formally announced that the government intended to implement a fixed "carbon tax" by July 2012 and intended to introduce legislation to do so by the second half of 2011.²³⁶ Details concerning the carbon tax scheme are minimal. All that has been proposed as of late February 2011 is:²³⁷

(a) The proposed commencement date for the Carbon Tax is 1 July 2012.

²³⁵ Multiparty Climate Change Committee, "Carbon Price Mechanism", 21 December 2010 (available online from <http://www.scribd.com/doc/49435346/MPCCC-Carbon-Price-Mechanism>).

²³⁶ Tim Leslie, "Gillard unveils carbon price details" ABC News, February 24, 2011 (<http://www.abc.net.au/news/stories/2011/02/24/3147523.htm>)

²³⁷ Deutsche Bank Australasia, "Australian Carbon Policy: Tax-then-trade to start July 2012" 24 February 2011.

- (b) The Carbon Tax would be fixed for 3-5 years after which it would be replaced by a cap and trade system, presumably the CPRS or some hybrid based on its 2009 form.
- (c) The following entities/activities will initially be subject to the Carbon Tax: (i) stationary energy sources such as power plants, (ii) transport, (iii) industrial processes, (iv) sources of fugitive emissions. Agricultural and land use activities that generate significant carbon emissions will not be taxed for their emission generating activities.

The proposal is notable for its surprising lack of detail. Given all of the debate and research completed for the CPRS, one would have expected a more detailed proposal to have been released by the government. It appears that political realities may have limited the government options. Tony Windsor, who is one of the two independent parliamentarians supporting the current Gillard/Labor Government, agreed to have the proposal released for public consultations but is decidedly against imposing a carbon tax at this time.²³⁸ The Greens on the other hand may have forced Gillard's hand by threatening to leave the government if she did not take meaningful action to pass a tax on carbon.

Public approval of the proposed carbon tax scheme is low if one considers the results of a NewsPol survey on public approval of political parties on the federal level and specific politicians. The results of NewsPol survey, which were published on March 7, 2011, indicated that the federal Labour Party and PM Gillard public approval ratings had fallen to "record lows".²³⁹ She is now less popular than previous Labor PM Kevin Rudd.

It remains to be seen how this twist in Australia's efforts to implement some form of carbon pollution reduction scheme will play out. In many ways, the political gridlock that has developed around the implementation of a cap and trade program in Australia is very similar to the situation that exists in the US, where carbon pollution reduction legislation stalled after failing to pass the US Senate in 2010. Such programs are proving very difficult to implement worldwide due to public misunderstanding of how these complex programs will affect their daily lives and the very accurate understandings of those industrial interest groups such as power, fuel production and industrial processing companies, which will be adversely impacted by any cap and trade program.

²³⁸ ABC News, "Windsor savages carbon tax strategy", 9 March 2011.
(<http://www.abc.net.au/news/stories/2011/03/09/3158764.htm?site=news>)

²³⁹ ABC News, "Gillard vows to fight after poll hammering", March 8, 2011.

3.5.2 Resource Super Profits Tax/Mineral Resources Rent Tax

Before the election could be held, however, Rudd attempted to impose a resource super profits tax (RSPT) on the mining industry. This turned out to be a huge political miscalculation on Rudd's part. Rudd announced the RSPT to the nation and the mining and natural resource industries in May 2010. Except for its total opposition to the tax, the mining community had a hard time voicing its specific complaints because there was so much still unknown about the proposed tax scheme. A fact sheet issued by the Australian government on the RSPT was embarrassingly short on details.²⁴⁰ An article in Sydney's *The Daily Telegraph* provided much clearer details on how the RSPT was expected to work than the government's own documents.²⁴¹

- A 40 percent tax will be imposed on all profits earned by mining as well as oil and gas extraction companies that earn a profit greater than 5.7 percent, which is the government's long-term bond rate.
- Profit was to be calculated after the deduction of royalties, operating expenses, depreciation, federal company tax, and a capital allowance of around \$5 million for each company.
- The federal company tax was to be reduced from 30 percent to 28 percent.
- If a company fails to make a profit, the Commonwealth government will reimburse that company for 40 percent of its initial investment in the mine.
- The tax will be applied retroactively.

The Commonwealth government expected to earn A\$12 billion in extra tax revenues starting in 2012 from the RSPT. The monies were to be used to "bail out" the government superannuation funds (about one-third of the RSPT revenues) and to finance transport infrastructure projects in NSW and Queensland.

As opposition to the RSPT grew in June 2010, rumors circulated that the Rudd government would offer a compromise to the mining sector, which would increase the threshold profit rate from 5.7 percent to 10 percent or 12 percent. It was also rumored that the Rudd government would drop the proposal to reimburse 40 percent of the cost of any failed mines. But these rumors were squashed on June 11, 2010, by Wayne Swan, the government treasurer, who

²⁴⁰ Australian Government, "Fact Sheet: Resource Super Profits Tax" (available at www.futuretax.gov.au/documents/attachments/10_Fact_sheet_Resource_Profit_Tax_Final.pdf).

²⁴¹ Andrew Carswell, "Your Simple Guide to the Resource Super Profits Tax," June 17, 2010.

announced that consultations with industry are ongoing and a final design would only be announced after these consultations have been completed.

Industry reactions to the RSPT were, as could be expected, uniformly negative. Many of those opposed to the tax and even some in favor of the tax felt that it was a hypocritical attempt by Rudd to position his government for the upcoming federal election in November 2010. In response to the proposed RSPT, Xstrata announced that its Wandoan coal project was on hold, which would have also delayed the Surat rail project and WICET. Coal miners such as BHP and others threatened to do the same.

Whatever Rudd's rationale for proposing the RSPT, it turned out to be a serious political miscalculation. In late June 2010, the Australian Labour Party, under considerable pressure from the public and declining in the polls, decided to remove Rudd as its choice for prime minister. He was replaced by his deputy, Julia Gillard, who took immediate action to remove the biggest issue of the election—the RSPT—from the table. She renamed the initiative the MRRT (for minerals resources rent tax) and changed its threshold values, in consultation with BHP and other large mining companies. She also moved up the date for the general election from October 2010 to August 2010. Labour managed to win the election by a narrow margin and then, against all odds, to cobble together a government by joining with two independents and one member of the Greens Party.

As of February 2011, Gillard's hold on power is considered by most Australian political analysts to be very weak with a new election likely sometime during 2011. Until the current "hung parliament" is decided in favor of either the National or the Labour party, it appears unlikely that either the MRRT or its new Carbon Tax proposal will gain much traction in the Australian parliament. Even if Gillard government were able to pass into law legislation in support of both measures, the Opposition has stated unequivocally that it will rescind both laws if voters, in the next general election, should give the Opposition sufficient votes to form the next government and have a majority in both the House and Senate. Given all of this political and regulatory uncertainty, it is hardly any wonder that major investment decisions to open new mines and to construct new rail and port infrastructure in Queensland and NSW are constantly being second-guessed by private investors and state governments.

4. New Technology to the Rescue?

In response to global warming and resource availability issues, the Australian government and the coal industry of Australia have decided to bank heavily on technology to solve their “greenhouse gas emission problems. Both coal and power companies in Australia are confronted with continued uncertainty over how and when national or international GHG mitigation policies could impact their businesses. As a result, the industry is examining several key technologies that might play a role in reducing both their emissions and their exposure to emissions mitigation policies: carbon capture and sequestration (CCS), coal bed methane (CBM), and underground coal gasification (UCG).

4.1 Carbon Capture and Sequestration

Carbon capture and sequestration (CCS) is a process for removing CO₂ from a stream of process gases, liquefying the CO₂, transporting it to a storage site and then injecting the liquid CO₂ deep underground into a geological formation that ensures safe and permanent storage.

The process consists of three generic technologies:

- CO₂ capture technologies, which remove CO₂ from either (a) syngas, which is produced through the gasification of coal or (b) flue gas, which is produced through the direct combustion of the coal, and then produce a concentrated stream of CO₂ that is compressed into liquid form prior to transport
- CO₂ transportation technologies, which utilize pipelines as a primary transportation method, though some CCS projects may rely on transportation of CO₂ by truck, ship or rail
- CO₂ sequestration technologies, which involve identifying acceptable geological formations and then injecting the liquid CO₂ into these geological formations for permanent storage

Of the three generic technologies, CO₂ capture technologies, which typically account for the greatest share of costs in the CCS value chain, have until recently received the lion’s share of government and industry attention and funding. Capture technologies have traditionally been separated into three distinct categories.

- (1) Precombustion technologies, which rely on downdraft gasifiers to convert the coal into a syngas of CO, H and CO₂ and then other technologies for removing the CO₂ from the

syngas stream and liquefying it.²⁴² Gasification is typically envisioned as being accomplished via an integrated gas combined cycle (IGCC) power plant, which produces electricity and process steam along with the stream of liquid CO₂.

- (2) Postcombustion solvent capture technologies, which rely on combustion of coal in a PC boiler and mixing the resulting flue gas from the combustion process with either chemical or physical solvents that have an affinity for CO₂. The combined solvent-CO₂ solution is then passed through a distillation column where the CO₂ is vaporized, collected as 100% CO₂ and then liquefied.
- (3) Oxy-fuel combustion, which produces a concentrated stream of almost pure CO₂ from the combustion of coal in a PC boiler an atmosphere of concentrated oxygen. The resulting flue gas is composed primarily of CO₂ and water. The concentrated CO₂ stream is then stripped of any remaining impurities and then compressed into a liquid.

Transportation technologies are technically proven and account for a small part of total CCS costs. They have therefore not received much government funding or attention as part of any government CCS R&D program. In short, they are not viewed as a critical technological constraint for CCS.²⁴³ The costs of CO₂ pipelines are analogous to those of natural gas pipelines, which have significant exposure to raw material input costs such as steel.²⁴⁴

Storage technologies actually refers to the geoscience research necessary for the identification of specific geological formations that pose the lowest risk of CO₂ leakage either into the atmosphere or the water table. Government funded research has focused on the delineation of areas that can provide the safe and long-term storage of CO₂.²⁴⁵ But due to growing public

²⁴² The CO is either burned with the H₂ to produce electricity or is passed over a catalyst in the presence of water (water shift conversion) to produce more H₂ and CO₂ and some CH₄ and more CO₂. Both streams of CO₂ are captured and liquefied.

²⁴³ It should be noted however that were CCS widely deployed across coal-fired plants in the US, the sheer size of the pipeline network likely required would be substantial and require massive investment. The US National Energy Technology Laboratory (NETL) analyzed the costs and barriers to a US CO₂ pipeline network in *A Policy, Legal, and Regulatory Evaluation of the Feasibility of a National Pipeline Infrastructure for the Transport and Storage of Carbon Dioxide*, available at <http://www.sseb.org/downloads/pipeline.pdf>.

²⁴⁴ *A Policy, Legal, and Regulatory Evaluation of the Feasibility of a National Pipeline Infrastructure for the Transport and Storage of Carbon Dioxide*, NETL 2010.

²⁴⁵ The US Department of Energy funds extensive research on carbon sequestration, much of which can be found at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIII/index.html. The National Energy Technology Laboratory's "2010 Carbon Sequestration Atlas of the United States and Canada – Third Edition (Atlas III)" is available at http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIII/index.html. Early research on China's storage potential has also been carried out by US national labs. The Pacific Northwest National Lab's estimate of China's CO₂ sequestration potential, "Regional Opportunities for Carbon

opposition to CCS projects that would store CO₂ on sites that are near to or under populated areas, governments are starting to address negative public perceptions about the environmental risks of terrestrial CO₂ storage. This very recent activity involves development of enhanced and comprehensive regulatory approval processes that focus on public consultations and education concerning the entire CCS project pathway including the environmental risks and regulatory approvals needed for all components of a CCS project, including geosequestration of CO₂ and its risks.²⁴⁶

CCS is widely recognized as a key technology for mitigating global carbon emissions (the majority of which come from burning coal). The US Secretary of Energy, Steven Chu, said in 2009 that because coal accounts for 40% of global emissions, “I believe we must make it our goal to advance carbon capture and storage technology to the point where widespread, affordable deployment can begin in 8 to 10 years.”²⁴⁷ IEA research shows that CCS will have to contribute 19% of global GHG mitigation to 2050—2% more than renewable energy at 17%—in order to stabilize the global climate.²⁴⁸ The IPCC argued that under a least-cost mitigation portfolio approach, CCS might contribute 15-55% of global mitigation before 2100 (depending on the scenario and assumptions).²⁴⁹ The IPCC further argued that including CCS in the global mitigation portfolio would reduce mitigation costs by 30% or more.²⁵⁰ Numerous industry groups also support the development of CCS technology, including the Electric Power Research Institute (EPRI), the World Coal Association, and even the World Wildlife Federation (WWF), which has voiced qualified support for funding CCS demonstration

Dioxide Capture and Storage in China: A Comprehensive CO₂ Storage Cost Curve and Analysis of the Potential for Large Scale Deployment of CCS in the People’s Republic of China”, is available at http://energyenvironment.pnl.gov/pdf/roccs_china_pnnl_19091.pdf.

²⁴⁶ For example, see recent work completed by the Scottish government with support from the Global CCS Institute located in Canberra, Australia *The Scottish Government, “Carbon Capture and Storage Regulatory Test Toolkit” and Carbon Capture, Transport and Storage Regulatory Test Exercise: 11 -12 August 2010 Output Report*” available at <http://www.globalccsinstitute.com>

²⁴⁷ Open letter from the US Secretary of Energy, October 12, 2009. Available at http://www.energy.gov/media/CCS_Letter_-_Final.pdf.

²⁴⁸ Analysis based on IEA’s *Energy Technology Perspectives 2010*. GHG reduction targets refer to IEA’s Blue Map Scenario.

²⁴⁹ IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 442.

²⁵⁰ IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 442.

projects as a means of determining if this technology can succeed.^{251,252,253,254} In short, addressing climate change requires addressing emissions from burning coal, and CCS is the leading candidate for achieving such CO₂ emission reductions.

Australia's CCS support program is an integrated effort that is being led by the Australian Government in partnership with a number of state governments, particularly the governments of Queensland, NSW and Victoria, and companies and industry trade groups with an interest in coal and its conversion into low GHG emission energy, such as the Australian Coal Association, the NSW Mineral Council, GE, MHI and Shell Oil Company.

The Australian Government is supporting the implementation of CCS demonstration and research through a special CCS fund, known as the CCS Flagships Program, which forms part of the government's broader A\$4.5 billion Clean Energy Initiative. The CCS Flagships Program was established in 2008, with initial funding of A\$1.85 billion. Its targeted goals are to: (a) support the development of two-to-four integrated industrial scale CCS projects; (b) "contribute to the development of at least 20 CCS projects by 2020" and (c) help establish "1000 MW of low emission fossil fuel power generation in Australia".²⁵⁵

The CCS Flagships Program is being implemented in two stages. Stage one, which was completed in December 2009, involved the solicitation of preliminary proposals from interested parties from which a shortlist of bidders allowed to compete in Stage two was selected. Stage two of the program is expected to commence sometime during the second half of 2011.²⁵⁶ The Australian Government expects that these funds will help leverage an additional \$4 billion of state and industry funding for the CCS demonstration projects.²⁵⁷

²⁵¹ International Energy Agency, "CO₂ Capture and Storage: A Key Carbon Abatement Option" 2008 and "Technology Roadmap: Carbon capture and storage" undated but believed to be issued in 2009.

²⁵² Electric Power Research Institute (EPRI), "Advanced Coal Plants, Capture and Storage", March 2011.

²⁵³ World Wildlife Federation "WWF joins world's leading environmental proponents in CCS call" 15 April 2008 (<http://www.wwf.org.au/news/wwf-joins-worlds-leading-environment-proponents-in-ccs-call/>).

²⁵⁴ World Coal Association "Carbon Capture and Storage" March 2011 (<http://www.worldcoal.org/carbon-capture-storage/>).

²⁵⁵ Australian Government: Department of Resources, Energy and Tourism, Carbon Capture and Storage Flagships Program Fact Sheet", 2010 (http://www.ret.gov.au/energy/Documents/cei/ccsfp/CCS_Fact_Sheet.pdf)

²⁵⁶ Ibid.

²⁵⁷ Ibid.

Based on potential support under the CCS Flagships Program and additional support available from state governments and from a special coal industry fund of A\$1 billion, which was generated from a voluntary levy paid by coal mining companies, a number of CCS projects are under development in Australia. Over 15 such projects were identified by CO2CRC,²⁵⁸ a research organization established as a collaboration of industry, government and research organizations, either in construction in Australia or at an advanced stage of planning as of January 2009.²⁵⁹

Since that listing was published other significant CCS projects have surfaced, such as the 400 MW Wandoan Power Project, which will develop a 400 MW IGCC-CCS project on a site that is close to Xstrata's Wandoan coal resource in the Surat Basin. The project, which is being developed by GE, will implement CCS technologies at commercial scale and will be capable of capturing 90% of CO₂ emissions using precombustion capture of CO₂. The Australian Government has also played a lead role in establishing the Global CCS Institute, which was launched in early 2009 with A\$100 million of funding from the Australian Government.²⁶⁰

The efforts of the Australian Government have been exemplary in both their scope and long-term commitment to CCS as a GHG reduction option. Nonetheless, the future of CCS in Australia and the rest of the World rests upon the R&D efforts and demonstration projects that are starting from a very early stage. The Government of Australia and industry proponents of different CCS technologies are making the expected shows of confidence as they announce the start of their projects and research programs.²⁶¹

But the Australia Government had not yet funded a single project under its CCS Flagships Program as of early 2011 and does not intend to request full project proposals from companies until the second half of 2011.²⁶² Moreover, a number of the proposed CO₂ capture technologies

²⁵⁸ CO2CRC, which is a research centre focused on CCS related research, was established in 2009 under the Australian Government's Cooperative Research Centre's Programme. It is a partnership between industry, state governments and various research organizations such as CSIRO and Australian universities.

²⁵⁹ Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) "CCS Activity in Australia, 2009" (http://www.co2crc.com.au/dls/gen/CCS_activities_2008.pdf)

²⁶⁰ GCCSI publishes reports a wide selection of technical and economic reports covering the status of global CCS projects, economics of CCS and many other matters of interest to those interested in CCS. These reports, which are of very high quality are available free of charge from the Global CCS Institute website (<http://www.globalccsinstitute.com>)

²⁶¹ Wandoan Power, "Wandoan Power Project Summary" (www.wandoanpower.com.au); ZeroGen "Project Overview" (<http://www.zerogen.com.au/project/overview.aspx>)

²⁶² Ibid.

under the Flagships Program are still at the demonstration stage and some are still at the pilot stage of development. Even proven post-combustion capture technologies, such as *monoethanolamine* (MEA) solvent extraction, face formidable challenges scaling up to a plant size sufficient to handle the huge volumes of dilute CO₂ gas streams generated by coal-fired power plants.

The impediments to wide-scale deployment of CCS are substantial. All CO₂ removal systems—both pre and post combustion systems—are likely to pose significant operating risks for power plants due to their need to rely on power plant auxiliary systems to remove CO₂. Even if one assumes that technology and cost issues are resolved at the single-plant level, significant technical and economic issues are also likely to emerge as countries attempt to widely implement these systems. In this author's view, constraints are also likely to emerge in the form of solvent and equipment shortages, leading to higher than expected costs for plants once their systems are fully demonstrated at commercial scale.

But societies will be lucky to reach that level of commercial deployment of CCS systems. Many of the technology options being explored today face the risk of failing the test of commercialization due to “inscalability” and poor operating efficiency. There is no guarantee that even one of the possible options will prove technically feasible at scale or whether CCS will ever be able to achieve CO₂ capture at an acceptable cost.²⁶³

In short, the ability to achieve the requisite economies of scale and improvements in efficiency for CCS processes is far from certain.²⁶⁴ But, a large challenge confronting CCS is that in order to address emission from the existing stock of coal-fired plants, the technology must be flexible enough to be retrofitted onto the existing global coal generation fleet.

²⁶³ A Stanford University study examined in detail the obstacles facing CCS deployment at scale in China, arguably the largest target market. See Morse, Rai, and He, “The Real Drivers of Carbon Capture and Storage in China”, Stanford University, 2009.

²⁶⁴ In addition to the IPCC report cited in this chapter, readers are referred to other sources that review existing and emerging CCS technologies:

- a. International Energy Agency, “Technology Roadmap: Carbon Capture and Storage” (undated);
- b. Clean Air Task Force, “Coal Without Carbon: An Investment Plan for Federal Action,” September 2009 (available from www.catf.us);
- c. Wilson, Elizabeth J., and David Gerard Wilson (eds.), “Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation,” Wiley-Blackwell, April 2007;
- d. Shackley, Simon, and Clair Gough (eds.), “Carbon Capture and its Storage: An Integrated Assessment,” Ashgate Publishing, December 2006.

Only post-combustion systems offer the possible option of retrofitting an existing power plant, as there are a very coal plants currently in existence that could be integrated with pre-combustion CCS. But retrofitting existing power plants, steel mills and industrial processing plants with post-combustion systems is at present prohibitively expensive and creates very large drops in a coal-fired power plant's efficiency (see Tables 10 and 11). Moreover, retrofits always involve additional costs due to the need to modify the power plant to accommodate the CO₂ capture system, which will, in most cases, experience sub-optimal performance due to site limitations and being bolted onto an already built facility.

As a result, governments that choose to implement CCS as a major plank of their CO₂ reduction programs will need to consider early retirement of existing coal-fired power plants and their replacement with new, more efficient coal-fired power plant equipped with CCS.. Moreover, CCS technologies—both pre and post combustion systems—will cause a significant increase in the consumption of coal with additional levels of CO₂ production (beyond the amounts of CO₂ produced on the same plant without CCS) as the price for its later capture and sequestration.

Australia, which relies on coal-fired power for 80% of its 2009 electricity generation and other countries such as the United States, China, and Indonesia, which also rely heavily on coal for power generation, will face significant increases in their power prices, if they follow through on CCS, due to the high cost of installing and operating CCS systems. The UN's Intergovernmental Panel on Climate Change (IPCC) estimates that the cost of electricity produced in a new supercritical power plant with CCS would be from 40 percent to 85 percent higher than a supercritical plant without CCS while a new integrated gas combined cycle (IGCC) plant would have its costs of production increased by 20 percent to 55 percent.²⁶⁵

The IEA estimated in 2008 that demonstration-scale post-combustion CCS plants would result in increases in the cost of generating electricity by \$0.08 – \$ 0.10 per kWh at the power plant's bus bar. CO₂ abatement costs would range from \$60-75 per tonne of CO₂ abated.²⁶⁶ If capital and operating and maintenance costs for a CCS plant were recovered through a tax on each

²⁶⁵ IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. It should be noted an IGCC plant without CCS has substantially higher costs of production than a supercritical plant without CCS. There are very few IGCC plants in operation. So switching from PC-type boiler plants to IGCC technology with CCS will still involve a huge increase in the cost of electricity.

²⁶⁶ International Energy Agency, "CO₂ Capture and Storage: A Key Carbon Abatement Option", 2008.

tonne of coal sold, the tax on coal would range from \$135.60 - \$169.50 per tonne for demonstration plants and would range from \$124.30 – 135.60 per tonne for commercial scale plants, which the IEA forecasts will only be available after 2030. All of these estimates assume 2008 price levels.²⁶⁷ Retrofitting existing plants, which will be largely plants equipped with subcritical boilers, will entail even greater increases in the price of electricity.

The Global CCS Institute has issued a detailed study which assesses the costs of CO₂ abatement and the increased price of electricity that will result from installing CCS on new power plants.²⁶⁸ Although the results are more promising than those reported by the IEA, McKinsey and Harvard, the costs of CO₂ abatement remain stubbornly high at \$44 - \$78 per tonne of CO₂ abated.²⁶⁹ This translates into a change in the coal price of over \$100 per tonne. Moreover, the authors of the Global CCS Institute study go to great lengths to explain the limits to their cost estimation methodologies and indicate that the estimates have a margin of error equal to +/- 40% with the greatest price risk being to the upside.²⁷⁰

Tables 9, 10, and 11 provide a critical analysis of CCS as an option for reducing CO₂ emissions from existing power plants, highlighting likely impediments for full-scale deployment of the technology.

- Table 9 separates the potential offered by CCS from the risks of where we are today in the development stages of each CCS technology.

²⁶⁷ The methodology for converting a CO₂ abatement cost into an additional coal price is as follows:

1. a tonne of CO₂ forms during coal combustion when one atom of carbon (C) unites with two atoms of oxygen (O) from the air.
2. The atomic weight of carbon is 12 and that of oxygen is 16, which makes the atomic weight of CO₂ is 44.
3. Assuming complete combustion, 1 tonne of carbon combines with 2.667 tonnes of oxygen to produce 3.667 tonnes of CO₂.
4. Each tonne of Australia's bituminous coal will contain around 700 kgs of carbon (70% C content) when measured from an Ultimate (elemental) Analysis of C, H, O and N and reported on a dry basis. Assuming that the coal has a total moisture content of 12%, the carbon content on an as received basis would be closer to 620 kgs per tonne of bituminous coal.
5. Each tonne of coal burned would therefore generate 2.26 tonnes of CO₂.
6. A cost of CO₂ abatement of \$60 per tonne therefore translates into an equivalent coal price adder of \$135.60 per tonne of CO₂ abated. (Coal Price Adder = \$60/tonne CO₂ abated x 2.26 tonnes CO₂/tonne of coal = \$135.60/tonne of coal) Source: Author's calculations using standard CO₂ estimation methods.

²⁶⁸ WorleyParson Services Pty Ltd, "Economic Assessment of Carbon Capture and Storage Technologies, 2011 Update"(report funded by the Global CCS Institute), 2011.

²⁶⁹ Ibid, p.7.

²⁷⁰ Ibid, p.11

- Table 10 shows for a coal-fired power plant located in Conesville, Indiana, the cost and technical performance impacts of retrofitting that power plant with an MEA-based CCS. Oxyfuel and other early-stage CO₂ abatement technologies would have even worse cost and performance implications.
- Table 11 provides a summary of the cost implications of applying CCS as reported by the IEA, McKinsey, Harvard University and Worley Parson.²⁷¹

Table 11: CCS Technology: Potential versus Risks

Potential	The Risks
1. Cost of CCS can be defrayed by putting CO ₂ to productive use: <ul style="list-style-type: none"> – enhanced oil recovery (EOR) – producing biomass (microalgae) – making cement 	<ul style="list-style-type: none"> • Markets that reuse CO₂: <ul style="list-style-type: none"> – are limited in size (EOR) – require low or zero cost CO₂ – must rely on uncompetitive and unproven technologies (algae, cement, oxy-fuel and MEA extraction)
2. New technologies will soon lower CCS costs and improve the efficiency of the carbon capture process.	<ul style="list-style-type: none"> • New CCS systems are still in the early test phase.
3. Up to 90% CO ₂ can be captured from existing power plants.	<ul style="list-style-type: none"> • 90% CO₂ capture as a retrofit technology comes at very high price. The retrofitted CO₂ extraction plant would <ul style="list-style-type: none"> – reduce power plant output by 10% and efficiency by ~ 30% – require extra capital costs ranging from \$1,319/kW to \$1,649/kW – increase the price of power by at least 60%
4. Captured CO ₂ can be safely	<ul style="list-style-type: none"> • Distance of such reservoirs from power

²⁷¹ See IEA, “CO₂ Capture and Storage: A Key Carbon Abatement Option”, 2008; Al-Juaied, Mohammed, and Adam Whitmore, “Realistic Costs of Carbon Capture,” Belfer Center for Science and International Affairs, Harvard Kennedy School, Harvard University, July 2009; McKinsey & Company “Carbon Capture and Storage: Assessing the Economics” (undated), and Worley Parsons Pty Ltd., “Economic Assessment of Carbon Capture and Storage Technologies, 2011 Update (funded and issued by Global CCS Institute).

sequestered for hundreds, if not thousands, of years, in saline formations and depleted oil wells.	<p>plant sites will limit applications.</p> <ul style="list-style-type: none"> • No long-term studies to confirm that CO₂ will be permanently sequestered.
5. Transport and injection technology will be well-understood and commercial.	<ul style="list-style-type: none"> • Private companies unlikely to take “long-term sequestration risk” without some form of government-backed indemnity.

Table 12: Impact of MEA Carbon Capture System w/90 Percent CO₂ Capture on Cost and Technical Performance of an Existing Coal-Fired Power Plant²

Performance Parameter	2001 Technology	2006 Technology	Future Technology	No CCS
Solvent Regeneration Energy (Btu/bm-CO ₂)	2350	1550	1200	n/a
New Plant Output (MW)	303	365	384	434
New Plant Efficiency (%)	20.2	24.4	25.7	35.0
Incremental Capex (\$/kW)	\$2,748 - \$3,435	\$1,319 - \$1,649	\$1,279 - \$ 1,600	n/a
Increase in LCOE due to CCS ¹ (c/kWh)	12.54	6.92	6.32	n/a
Cost of CO ₂ Abated (US\$/tonne)	\$127	\$89	\$85	n/a
Cost of CO ₂ Capture	\$84	\$59	\$56	n/a

1. New Coal-Fired Power Plant assumed to have levelized cost of electricity (LCOE) of 6.4 c/kWh
2. AEP Conesville (Ind.) #5 Unit used as case study

Source: NETL “Carbon Dioxide Capture from Existing Coal-Fired Power Plants: Final Report” November 2007.

Table 13: Recent Cost Estimates for CO₂ Abatement Using CCS (supercritical PC plant)

IEA ,CO₂ Capture and Storage: A Key Carbon Abatement Option, 2008	Harvard/McKinsey/Global CCS Institute Studies
<p>Demo Plants (2010)</p> <ul style="list-style-type: none"> • \$60-75/t CO₂ abated • ↑ in Electricity Price - \$0.08 -\$0.10/kWh (2008 prices) <p>Competitive Commercial Scale Plants (2030+)</p> <ul style="list-style-type: none"> • \$55 -65/t CO₂ abated • ↑ in Electricity Price (2030-50/ Blue Map Scenario) <ul style="list-style-type: none"> – Average ↑ 90% – Range ↑ 65 - 163% 	<p>Demo (Power) Plants (2010-2020)</p> <ul style="list-style-type: none"> • \$80 - 120/t CO₂ abated (McKinsey) • \$120 - \$180/t CO₂ abated (Harvard) • \$47 -\$81/t CO₂ abated (GCCSI) • ↑ in Electricity Price - \$0.08 - \$0.10/kWh (Harvard, 2008 prices) • ↑ In Electricity Price -\$0.05 - \$0.06/kWh (GCCSI 2010 Prices) <p>Competitive Commercial Scale Plants (2020+)</p> <ul style="list-style-type: none"> • \$40 – 60/t CO₂ abated (McKinsey) • \$35 – 70/t CO₂ abated (Harvard) • \$44 – 78/t CO₂ abated (GCCSI) • ↑ Electricity Price- \$0.02 \$0.05/ kWh (Harvard, 2008 prices) • ↑ Electricity Price- \$0.04- \$0.05/ kWh (GCCSI, 2010 prices)

Unless an unexpected CCS technology breakthrough occurs, any government that chooses to rely on CCS to address its CO₂emission problem is, in this author's view, exposing its economy to high technical and economic risks. Due to the high risks and costs associated with CCS, other technology opportunities are likely to gain market share as alternatives. Several sustainable alternatives are discussed in the following two sections.

4.2 CBM as an Alternative to CCS

Coal bed methane (CBM)²⁷² could provide a cost-effective alternative to CCS by serving as the low carbon fuel for new power plants that will be built as Australia's aging coal-fired power plants are retired.²⁷³ In addition to its lower GHG impacts, CBM, along with UCG, has the potential to diversify the ownership and broaden the structure of Australia's coal industry as well as the mix of energy products that it offers to its customers.

4.2.1 CBM Resources of Queensland and NSW

The states of Queensland, NSW, and South Australia contain huge untapped reservoirs of CBM. Commercial production of CBM is a relatively recent development in Australia, which did not reach a significant scale until 2005.²⁷⁴ Since then, the rate at which new proved + probable (2P) reserves are being booked and production is being ramped up has been breathtaking.²⁷⁵

With respect to 2P reserves, most CBM reserves have been "booked" in Queensland, which at the end of June 30, 2009, were estimated to be 18,289 PJ, a 160 percent increase over the level of 2P reserves reported at the end of calendar year 2007 (7,052 PJ).²⁷⁶ Queensland currently

²⁷² Coal Bed Methane (CBM), also known as coal seam gas or CSG in Australia, refers to methane that has been adsorbed in a near-liquid state inside the pores and fractures or cleats of the "solid matrix" of unmined coal. The size of a particular CBM source depends on (a) the rank of the coal as measured by its vitrinite reflectance number (a VN# of 0.8 percent to 1.5 percent suggests a high CBM potential); (b) fracture permeability, which is dependent on the types and extent of fractures or cleats in the coal seams; (c) porosity of the coal bed reservoir, which is usually very low, ranging from 0.1 percent to 10 percent; and (d) adsorption capacity, defined as the volume of gas adsorbed per unit mass of coal usually expressed in SCF CBM/tonne of coal.

²⁷³ CBM is 90% methane and has a carbon content roughly one half of coal and one third lower than diesel and other petroleum products.

²⁷⁴ In February 1996, BHP Pty., Ltd. attempted the first commercial coal mine methane (CMM) operation commenced at the Moura mine in Queensland as part of a methane drainage project. In the same year, BHP also implemented CMM projects at its [Appin](#) and [Tower](#) underground mines with the collected CMM used to fuel on-site power generators. The first stand-alone commercial production of CBM in Australia commenced in December 1996 at the Dawson Valley project, which was then owned by Conoco, adjoining the Moura coal mine.

²⁷⁵ Proved and probable reserves with a 50 percent probability that the gas can be economically recovered (<http://www.dip.qld.gov.au/resources/factsheet/lng/lng-reserves-and-resources.pdf>).

²⁷⁶ Queensland Government, Department of Mines and Energy: "Queensland's coal seam gas overview: April 2010 (www.dme.qld.gov.au/zone_file_pdf/new_csg_cc.pdf).

accounts for 94 percent of Australia's 2P CBM reserves (7,050 PJ) and 96 percent of its 2008 CBM production (138.5PJ). The remaining 450 PJ of 2P reserves were located in NSW.

The growth in the Queensland's 2P CBM reserves has been astonishing when one considers that they stood at 4,640 PJ at the end of 2005 and were probably close to nil in 2004.

Geoscience Australia estimated the life of the 2008 2P CBM reserves at 115 years at the 2008 extraction rate of 138.5 PJ. Geoscience Australia estimates that CBM met 80 percent of Queensland 2008 gas requirements. The industry is growing so fast that one cannot keep up with the new levels of record production, reserves, and mega-LNG projects that CBM companies such as Arrow Energy, Santos, and others are announcing each week in Queensland.

4.2.2 Role of Improved Drilling and Seismic Technology

Advances in general exploration and drilling know-how have contributed greatly to the growth of Australia's budding CBM industry. With respect to improvements in the areas of exploration and drilling methods, most of them would be characterized as mundane, if not pedestrian sounding, improvements in technical expertise for developing the CBM resources. Specific know-how improvements include the following:

- Improved ability to interpret seismic and core sample data and in particular to determine where the "CBM fairways" are located and their likely productivity
- Greater expertise in drilling horizontal directional wells (HDD), which is constantly improving as the base of experienced drillers grows and as greater experience is gained in specific basins

Advances in technology that contributed to the growth in Australia's CBM production include

- improved down-hole drilling motors, known as mud motors because they are driven by the hydraulic force of the drilling mud being pumped through the drill pipe and through the motor, which allows the bit to be rotated at the bottom of the hole while the drill pipe remains stationary; and
- improved "in-hole" measurement devices that allow directional data to be sent back by telemetry and for the drill bit and the drilling motor to be guided electronically.

The end result is that in-seam HDD wells are being drilled more quickly and more accurately than ever before. As drilling companies and their field teams gain more experience working with the geological conditions of specific coal basins, the cost of drilling each well is expected to drop over the next five to six years.

The proactive involvement of the Queensland government in resolving overlapping claims has also contributed to the rapid growth of the CBM industry in Queensland. These issues were largely resolved under the Petroleum and Gas (Production and Safety) Act of 2004 and related amendments that were made to the Mineral Resources Act of 1989 and subsequent guidelines on “coordination agreements” that should be considered by parties to an overlapping claim dispute. In addition, the holder of a petroleum license (PL) was provided a more favorable priority over the holder of a mining license (ML) in any dispute resolution proceeding, if the two parties cannot reach an agreement on their own. The new and booming CBM industry that has developed in Queensland appears to be finally spreading to the state of NSW, where CBM projects languished due to a lack of government initiative to resolve problems related to overlapping claims to the same tenement.²⁷⁷

4.2.3 Case Study for Arrow/Dart Energy

Up-to-date (January 2011), industry-wide data on CBM reserves and production are not available from either the Queensland or NSW governments. Nonetheless, a good picture of the ongoing, torrid pace of CBM development of Queensland’s CBM industry can be obtained by examining the public documents of Dart Energy, which was until 2010 known as Arrow Energy.²⁷⁸ Dart Energy is currently Australia’s largest holder of coal seam gas acreage with interests in more than 65,000 km² of resource area. As of June 2010, Dart Energy was supplying 20 percent of Queensland’s gas production.

²⁷⁷ NSW has yet to amend its Petroleum Act to provide the same level of clarity and this may be one of the main reasons for the delay in the development of its CBM industry. Queensland, on the other hand, implemented a transparent process for resolving disputes that might occur between a mining company with a claim to specific coal mining claim to a tenement and an independent CBM company that wishes to develop that same tenement under a petroleum exploration and development license. The process is enshrined in the Petroleum and Gas (Production and Safety) Act 2004 (P&G 2004) and supporting amendments to the Mineral Resources Act of 1989. In addition, Queensland’s Department of Mines and Energy issued draft guidelines describing different types of coordination agreements that disputing parties should discuss among themselves before asking the minister to intervene and decide among the warring parties. Finally, the P&G 2004 gave to the holder of the petroleum license (PL) a “preferred” position in any dispute resolution proceeding over the holder of a mining license (ML).

²⁷⁸ In August 2010, Shell Oil Company, which was Arrow Energy’s largest shareholder, and PetroChina purchased the remaining shares of Arrow Energy for A\$4.70 per share, which was reported to be a 35 percent premium over the weighted average share price one month prior to the initial offer. It also involved existing shareholders receiving one Dart Energy share for every two Arrow Energy shares. Once the deal was closed, Shell and Petro China renamed Arrow Energy as Dart Energy.

Arrow Energy went public in August 2000 with an IPO that netted it a mere A\$5 million. By August 2009, Arrow had a market capitalization of A\$2.4 billion. What makes this growth in value even more impressive is that Arrow did not achieve its first production (and sale) of CBM until January 2006, when it brought its Kogan North CBM field into commercial operation. Despite the worldwide financial crisis, FY 2009 was another bumper year for Arrow Energy. In September 2009, the company announced plans to supply 55 PJ/y of CBM to the first train of a 2 x 1.5 mtpa LNG facility at Fisherman's Landing within the Port of Gladstone. The first train of the facility is expected to become operational by 2012. Toyota Tsusho has already signed a heads of agreement to buy the full output from the first train of the LNG plant. Arrow, prior to its acquisition by Shell and Petro China, had also announced plans for a drilling program to confirm 2P reserves sufficient to support a second LNG plant that will be constructed by Shell at the Port of Gladstone.

Table 12 shows Arrow Energy's extraordinary growth in both reserves and gas output from 2006 through February 2009. In fewer than two calendar years, Arrow increased its gross 2P reserves by 375 percent from 719 PJ at the end of FY 2006/2007 (meaning June 30, 2007) to 2,692 PJ by the end of February 2009. It has also expanded production from 10.4 PJ at the end of FY2006/2007 to 28.6 PJ by the end of FY 2007/08, a 275 percent increase over a period of only one year. Production and 2P reserves would be at even higher levels if only domestic markets were sufficient to take any increased production.

As a result of domestic market constraints, Dart will sell its gas to a 2 x 1.5 mtpa LNG facility at the Port of Gladstone with an expected commercial operation date of April 2012. Detailed information on CBM reserves and production was not available from the public filings of other large CBM producers such as Origin Energy, Queensland Gas, and Santos. But the story would probably be the same — extraordinary levels of growth over a relatively short period of time. More than 90 percent of Dart's acreage was still to be certified as of June 30, 2010, which means that these reserve figures are destined to grow even larger over time.

Table 14: Growth in Dart's CBM Resources, Reserves, and Production, FYs 2006-2009

	FY 2005/06		FY 2006/07		FY 2007/08		FY 2008/09		FY 2009/10	
	FY 2005/06	June 30, 2006	FY 2007/08	June 30, 2007	FY 2007/08	June 30, 2008	FY 2008/09	June 30, 2009	FY 2009/10 (@ 12/09)	Dec 30, 2009
Reserves (in PJ)										
1P (Proved)		25		86		427		703		808
2P (Proved+Probable)		166		716		2,247		4,092		6,150
3P (Proved+Probable+Possible)		2,148		2,760		5,084		9,312		11,042
Production (in PJ)	1.0		10.4		28.6		32.4		38.8 (annualized result) ^Ω	
Producing Wells		50		243		281		n/a		n/a

Sources: Arrow Energy, “Annual Reports for FY 2006 through 2008” and “Half-Year Financial Statements FY 2010 (issued February 17, 2010)” for FY 2009/2010.

Ω Production estimate for FY 2009/2010 = two times the half-year result. This is a very conservative estimate but even if it should come to pass, it would still represent a 20 percent increase over the previous FY.

4.2.4 Environmental Impacts of CBM Development

The most significant environmental impact caused by CBM wells is from the associated water that is pumped out the well in order to start and later maintain production. Due to the high concentrations of dissolved solids in the associated CBM water, if not properly handled, the associated water could pollute surface water and even nearby sub-surface groundwater.

Removing the water cap from above the coal seams may also depress aquifers over a large area and affect groundwater flows.

In Queensland, water produced during CBM production was, until 2009, pumped into large ponds and allowed to evaporate.²⁷⁹ On May 14, 2009, the government of Queensland issued a set of rules and procedures that put a stop to this practice.²⁸⁰ The rationale for its decision was ironically the success of the CBM industry. In 2007, CBM companies produced 12.5 gigaliters (GL) of associated water, which was already a significant quantity of waste water. However, once the Surat Basin CBM deposits are developed, the government of Queensland estimates that the quantity of associated water will reach 25 GL per year for the next 25 years. This associated water forecast does not take into account the recent attempts by CBM manufacturers to develop CBM resources to supply to LNG facilities at the Port of Gladstone, which will add to the associated water production estimate.

The government of Queensland estimated in 2009 that, if it allowed the practice of CBM associated water being stored in open ponds to continue, 25 km² of land would be required to hold the estimated 25 GL per year of water produced by the CBM industry.²⁸¹ This estimate, which assumed the waste water was held in two-meter deep evaporation ponds, did not include an allowance for land, which must be used for managing safety, maintaining the ponds, and allowing for catchment of rainfall. If CBM producers were successful in developing their LNG export business using CBM, associated water production would have increased to levels of up to 100 GL per year, which would require a minimum of 100 km² of land area to be dedicated to

²⁷⁹ Because the associated water contains high levels of dissolved solids, such as sodium bicarbonate and chloride, it is not suitable for either human or animal consumption.

²⁸⁰ Queensland Government: "Management of Water Produced from Coal Seam Gas Production: Discussion Paper," May 2009 (available through www.dip.qld.gov.au).

²⁸¹ Ibid.

evaporation ponds over the next 30 years. It will also produce over time 7.5 million tonnes of dry salts from the saline effluent.²⁸²

As a result of these findings, the government of Queensland disallowed the use of evaporation ponds as a means of disposing of CBM-associated water. If the water was not re-injected into the ground in an environmentally sound manner or if it could not be put to some beneficial use, CBM producers now needed, at their expense, to treat the associated CBM water and dispose of any saline effluent (if such effluent has a saline content greater than 10,000 TDS) “to a standard defined by [Australia’s] Environmental Protection Agency.”²⁸³ CBM producers with existing evaporation ponds are required to remediate these ponds within three years from May 2009.

Recently, a number of gas companies have commenced operating water treatment plants to treat the water to a point that it is safe enough for discharge into streams. In a few cases, the CBM companies have initiated water treatment projects that allow the water to be used as a source of domestic water supply and/or as cooling water for power stations. In these cases, the CBM companies have applied reverse osmosis to treat the product water.

4.3 Underground Coal Gasification

Underground coal gasification (UCG) refers to an in situ process for converting coal into a synthetic gas through partial oxidation. Once the coal is partially oxidized, the resulting gas is then extracted from the underground “gasifier,” cleaned of particulates, water, tars, and other impurities, and sold as either a power plant fuel or as a feedstock to the chemical industry for the production of ammonia, methanol, and other chemicals. UCG has four main attractive properties:

- It uses coals that are stranded, i.e., located below economic basement for either open-cut or underground mining.
- It achieves much greater energy removal rates than standard mining methods by a factor of 15 and even greater energy removal rates when compared with CBM.
- It leaves ash and unburned carbon in the ground.

²⁸² Ibid.

²⁸³ Ibid.

- It eliminates the cost of mining the coal and investing in an aboveground gasifier and water shift reactor.

UCG technology might allow the economic recovery of CO₂ using CCS technology due to the highly concentrated streams of CO₂ contained in the syngas produced by a UCG facility. Passing concentrated streams of CO₂ through CCS capture facilities will allow less costly capture technologies to be used in association with UCG plants.

The first commercial-scale UCG facility was implemented in Uzbekistan in 1960, when it was still part of the former Soviet Union. For almost 50 years, the Uzbekistan project has been the single, largest semi-commercial-demonstration of UCG technology in the world. UCG became a subject of interest in Australia in the late 1970s after the second oil shock of 1978. Based on U.S. interest in synthetic fuels, a number of Australian university professors started to track development of UCG technology in the United States. The leading proponent of UCG technology through the 1980s was a professor from the University of New South Wales named Ian Smith.

Professor Smith pushed for government support of UCG technology in the late 1970s. He was rewarded with contracts from the governments of NSW and South Australia to study the feasibility of developing a UCG demonstration program. In 1984, Smith issued his report to the government of New South Wales titled “In Situ Gasification of Coal for Australia”. In that report, he concluded the following:

- UCG was a proven technology.
- Its successful application in Australia could lead to the development of a cost-competitive synthetic fuels industry in Australia and export of the technology worldwide.

In 1984, Smith tried to take his advocacy a step further by recommending in his report to the government of South Australia that it utilize UCG technology at the existing Leigh Creek coal mine to produce gas for a power plant. He concluded in his engineering feasibility study that the cost of producing power from synthetic gas produced by the UCG process was economically competitive against the price of power from a conventional coal-fired power plant. However, at

the time Smith issued his reports, world oil prices were starting their steep, two-decade-long decline and all interest in the UCG concept was lost. Both governments refused to fund further research into UCG technology.

4.3.1 Linc Energy

From 1984 until around 1996, UCG was largely relegated to the back burner. In 1996, interest in UCG remerged with the establishment of Linc Energy by Len Walker, one of Ian Smith's students who worked on the Leigh Creek feasibility study in 1984.²⁸⁴ In 1996, Walker convinced investors to fund the establishment of Linc Energy, for which he served as CEO until 2002. During his six-year tenure, he established an association with Ergo Energy Technologies of Montreal (Ergo), at that time a UCG technology leader.

The two companies obtained private and government funding to conduct a test burn using Ergo's UCG technology at Linc Energy's test site in the Surat Basin near the town of Chinchilla.²⁸⁵ The test burn, which was successfully conducted over a three-year period (1999-2002), was the first extended UCG demonstration outside of the former Soviet Union. It gasified 35,000 tonnes of coal without violating any of its environmental clearances. Although the test burn was a technical success, due to the low oil prices of that time Linc was unable to obtain additional funding for taking the project to commercial scale. It therefore needed to decommission the test facility in 2002 and in that same year, Walker left Linc Energy to pursue other interests.

The company was later acquired by Australian entrepreneur Peter Bond, who took the company public on the ASX in October 2006. He also dropped the company's association with Ergo Energy Technologies and acquired the Uzbeki company that developed the first commercial UCG project. Finally, he has shifted Linc's focus from using UCG-produced syngas for power production to the production of liquid fuels. A picture of the demonstration gas to liquids plant is shown in Figure 32.

²⁸⁴ Between 1989 and 1996, Walker completed a series of self-funded UCG-to-power studies, which convinced him of the technical feasibility and economic potentials for UCG in Australia.

²⁸⁵ Ergo Exergy's technology was a variation on the theme of the former Soviet Union technology applied in Uzbekistan.

Figure 32: Linc Energy GTL Plant in Chinchilla



Source: <http://www.lincenergy.com/>

4.3.2 Carbon Energy

Carbon Energy, which is also listed on the ASX, trades under the symbol CNX. Prior to June 23, 2008, Carbon Energy was named Coal Gas Corporation, which was a fifty-fifty joint venture between Metex Resources Ltd. (Metex), a mining company that specialized in the development of gold deposits, and CSIRO, the Australian government research organization that held the rights and the title to special UCG technology, as well as various licenses to operate that technology.²⁸⁶ Carbon Energy in early 2008 became a 100-percent-owned subsidiary of Metex, with CSIRO holding its prior ownership in CGC in Metex. In June 2008, the company name was changed from Metex to Carbon Energy.

Carbon Energy's UCG technology is known as controlled retraction injection point (CRIP), which the U.S. DOE successfully demonstrated at its Rocky Mountain test facility in Colorado in

²⁸⁶ <http://www.carbonenergy.com.au/index.php/about-us/history>.

1988.²⁸⁷ CSIRO made various improvements to this system, obtained patents to the technology, and sold the rights to the technology to Metex.

The Carbon Energy UCG technology differs significantly from the systems being applied by Linc and another competitor named Cougar. Specific differences are as follows:

- (a) injection of oxygen rather than air into the gasification chamber or cavity, which allows for higher levels of methane production and lower NOx emissions;
- (b) use of horizontal directional drilling, rather than vertical wells, to position inlet and outlet pipelines into the coal seams to be gasified;
- (c) adoption of the CRIP system to achieve continuous retraction of the inlet and outlet pipes during the gasification process; and
- (d) application of advanced geological models and simulation tools for designing the UCG modules and then monitoring their performance.

Carbon Energy claims that its application of these advanced technologies and methods allows for finer control of the in situ gasification process and therefore the production of better quality gas and control of any environmental impacts.

Between December 2008 and April 2009, Carbon Energy successfully demonstrated the technical feasibility of its CRIP UCG process at its Bloodworth Creek demonstration site.²⁸⁸ The facility design was based upon the U.S. DOE experience at its RM-1 demonstration facility during the 1980s. Carbon Energy claims that improvements it has made to the U.S. DOE CRIP system have moved the technology “from an experimental stage to commercial reality.” The trial was performed using a UCG module that was sized to generate 1 PJ (petajoule) per year of syngas with a three-year module life, which was sufficient to fire a 20 MW combined-cycle

²⁸⁷ The “CRIP” system involves the use of direction drilling to create a channel that connects the production well to the injection well. A gasification cavity forms at the end of the injection well in the horizontal section of the coal seam. Once the coal in the cavity area is expended, the injection point is withdrawn (usually by burning a section of the liner) and a new gasification cavity is initiated. (Clean Air Task Force, “Coal Without Carbon: An Investment Plan for Federal Action: Expert Reports on Research, Development, and Demonstration for Affordable Carbon Capture and Sequestration,” September 2009).

²⁸⁸ Carbon Energy holds mining leases in the Surat Basin at a location called Bloodworth, which is located 55 km west of Dalby in southeast Queensland. The Bloodworth site reportedly contains more than 600 mt of JORC-certified resources.

gas-turbine power plant. The 100-day field trial demonstrated that the Carbon Energy process could produce a sustainable supply of syngas of consistent quality without causing unacceptable environmental impacts.

At the end of the trial, the module, now known as UCG Panel 1, was placed on standby mode while surface facilities for commercial production were put in place. The plan was to restart the UCG Panel 1 and use the gas to fire a 5x1 reciprocating engine power plant by January 2010. However this scheduled date for restarting syngas production from Panel 1 was recently rescheduled due to a delay in completing remediation work on the injection well to Panel 1, which became blocked toward the end of the demonstration project. Carbon Energy has not provided a firm date for restarting Panel 1 but as a contingency has proceeded with the design and construction of Panel 2 in case its remediation efforts on Panel 1 are unsuccessful.²⁸⁹

In December 2009, Carbon Energy provided estimates of independent gas reserve at its Bloodworth Creek test site based on Society of Petroleum Engineers guidelines for converting coal into syngas for two of the tenements that form part of the Bloodworth Creek site. The reserves as of December 2009 are as follows:

(a) 1P Reserve (Proven)	11.0 PJ
(b) 2P Reserve (Proven + Probable)	743.9 PJ
(c) 3P Reserve (Proven + Probable + Possible)	1,042.8 PJ

The reserve certificate includes those resources that are contained within 20 percent of the area covered by Carbon Energy's mining development license issued for the Bloodworth Creek area. It expects the 2P reserve estimates to increase over the next few years as more exploratory drilling is completed in the area.

Earlier in 2008, Carbon Energy executed a memorandum of understanding (MOU) with Incitec Pivot Ltd. (IPL), a manufacturer of ammonia and ammonia-based derivatives. The MOU states

²⁸⁹ Carbon Energy, "ASX Announcement: Australia's First UCG Syngas Power Station - Commissioning Update," March 3, 2010.

that both companies intend to form a joint venture company upon the successful conclusion of Carbon Energy's field trial at its Bloodworth site. The MOU also provides IPL with exclusive global rights to the use of Carbon Energy's UCG technology for the manufacture of ammonia and ammonia-derived products.

4.3.3 Cougar Energy

Cougar Energy Limited is a publicly listed Australian company that trades on the Australian Stock Exchange (ASX) industrials board under the code CXY. Cougar Energy was established in 2006 by Len Walker, the original founder of Linc Energy. The technology being applied by Cougar Energy is a variation of the old Soviet technology that is also being applied by Linc Energy. Cougar Energy has a licensing agreement with Ergo Exergy Technologies of Canada for the provision of Ergo Exergy's UCG technology to all UCG projects to be developed by Cougar Energy Ltd.

Cougar attempted a UCG test burn project at its Kingaroy site in Queensland. The plan was to use this site to develop a 400 MW power station with an initial capacity of 186 MW (gross). Cougar attempted the UCG test burn in January 2010 at its Kingaroy site. Cougar's intention was to use the test burn results as the basis for proceeding to the next stage of the project's development—the preparation of a bank feasibility study and solicitation of bank financing. Once funding was obtained, Cougar intended to commence construction of the power plant and a commercial scale UCG facility. The Kingaroy site, which is located 10 km south of the township of Kingaroy, was reported to contain a JORC-compliant resource of 73 million tonnes with two primary seams at depths of 130 to 300 meters and having thicknesses of 5 to 17 meters, which would have been sufficient to support the power plant project for 30 years.

Unfortunately, the test burn did not proceed in accordance with the terms of its environmental permit. Very low levels of benzene and toluene were detected in groundwater samples taken from test wells located next to the test burn site. Cougar was forced to shut down its test burn and to conduct additional tests for benzene and toluene over the following four to six months. According to Cougar, these new test results showed that the earlier test may have been transitory readings, as new results showed benzene and toluene to be at undetectable levels. The

Queensland Department of Environmental Resource Management (DERM) is still considering the most recent test results. Until a final DERM decision is made, the Cougar test burn site remains on standby. In the meantime, Cougar has managed to obtain a sizable investment from a Chinese resource company, which is interested in applying the UCG process followed by Cougar at various Chinese coal sites.

5. Into the Future

At the beginning of the 1950s, there were many sceptics who felt that Australia's black coal industry would never amount to much due to the actions of radical trade unions and the competitive threat posed by cheap oil. However, the post-WWII history of Australia's black coal industry has turned out to be a Cinderella story come true. The story of its recovery from a threatened and declining industry in the early 1950s to the world's largest black coal exporter in 1984 is a phenomenal success story, especially when one considers the barriers to development posed by Australia's radical trade unions prior to 1950 and cheap oil through the early 1970s.

One can cite many reasons why this successful transformation of the coal industry occurred. But the foremost reason is undoubtedly the proactive steps taken by the state governments of NSW and Queensland that either corrected past deficiencies of the industry (NSW) or implemented policies that supported the cost-effective and timely new mining developments (Queensland). These industry and government actions coupled with strong demand from Japan for high-quality coking coal and, after 1978, for steam coal occurred during the rapid growth phase of the industry, which lasted from 1960 to 1986.

The rebirth of Australia's black coal industry was also made possible by the following:

- The discovery of vast deposits of high-quality coking and steam coals in the Bowen Basin area of Queensland and the Hunter Valley area of NSW. It was also helpful that many of these new deposits were amenable to open-cut mining and located within a reasonable distance of deep sea ports.
- The availability of advanced technologies for discovering these and other black coal deposits and then mining them using either open-cut mining methods or advanced underground mining methods. The aggressive application of these advanced technologies led to huge increases in mine worker productivity and led to low-cost development of its black coal resources.
- The economic expansions of Korea and Taiwan (1980-1995) and the twin oil price shocks of the 1970s, which created huge export markets for Australia's steam coal.

By the end of the 26-year rapid growth phase, Australia became not only the world's largest black coal exporter, but also achieved a substantial diversification of its customer base and product offerings with the following achievements:²⁹⁰

- Exports in 1986 accounted for 69 percent of total sales compared with only 9 percent in 1960.
- Steam coal supplied 48 percent of total exports in 1986, up from less than 1 percent in 1960.
- Queensland emerged as Australia's largest exporter of black coal, jumping from 48,000 tonnes (less than 3 percent of total exports) in 1960 to 50.8 mt (57 percent of total exports) in 1984.
- Japan's share of total exports was reduced from 90 percent of total exports in 1960 to 45 percent in 1986.

During the industry's competitive phase (1987-2009), Australia's black coal industry experienced a dramatic slowing in its annual rate of growth. This slowing in growth was mainly due to supply-side factors such as the entry of Indonesia as a significant exporter of steam coal and the inability of the governments of NSW and Queensland to increase their ports and railway systems fast enough. This slowdown in the industry's rate of expansion affected both domestic consumption and exports. The competitive phase was also a time when both Queensland and NSW made significant changes to their regulatory frameworks, with Queensland first passing into law its Mineral Resources Act of 1988. NSW followed with the Mining Act of 1992. During the 1990s, the Commonwealth government lifted controls on export prices for coal (1993) and started to discuss greenhouse gas issues as a serious public policy issue (1996).

With the move into the volatile price phase, Australia's black coal industry is positioned to expand its market share but will need to implement more effective measures for dealing with the many challenges that threaten its position as the world's largest black coal exporter.

²⁹⁰ Joint Coal Board, "Black Coal in Australia, 1986-87," Table 1, p. 5; Table 100, p. 97; and Table 101, p. 99; and Annual Report of the Joint Coal Board, 1960-61, Table 10, p. 134.

5.1 Sufficient Reserves and Resources Exist

The states of NSW and Queensland have sufficient black coal resources, known as economic demonstrated resources (EDRs) that will allow Australia to sustain its 2008 level of raw coal production (438 million tonnes) for 90 years. Resources under development in the Galilee, Gunnedah, and Surat basins by Hancock Coal, Syntech Resources, Waratah Coal, Xstrata, and others will add to the impressive EDR totals and sustainable production period.

Coals from the three largely undeveloped basins of Galilee, Gunnedah, and Surat are mostly steam coals and hence the share of steam coal in the overall mix of black coal exports is also likely to grow significantly over the next two decades. If the two “advanced-stage” Surat Basin projects and the two Galilee Basin projects were to enter commercial operation on schedule, Queensland could be producing an additional 110 mtpa of steam coal by 2015. To put this figure in perspective, Australia exported 115 mt of steam coal in 2008.

5.2 But Infrastructure Constraints and Regulatory Uncertainty Are Delaying Expansion Efforts

The most pressing and immediate technical challenge to the black coal industry of Australia is the shortage of rail and port infrastructure to support its further growth. The governments of Queensland and NSW have proposed projects for expanding their rail and port networks to support a significant level of new black coal mining developments. If these proposed infrastructure expansions were implemented according to their 2008 schedules, NSW and Queensland could increase their combined exports of steam and coking coal from 240 million tonnes in 2010 to close to 540 million tonnes by 2020.²⁹¹

However, schedule adherence in today’s planning and fiscal environments is highly unlikely for either Queensland or NSW. Part of the reason that chronic infrastructure shortages are likely to persist has to do with the type of technology being implemented — large rail and fixed land port systems. In an attempt to maximize economies of scale for mining and transport projects, port and rail expansion projects need to be very large in scale. This means that first costs for such

²⁹¹ This estimate assumes that the rail and port infrastructure project outlined on Table 5 and Figure 21 proceed according to schedule and that port capacity is used at 90 percent of its nameplate capacity.

projects are very high first costs, lead times are long, and regulatory clearances are complex. The scale effects of these projects add to the sense of uncertainty and difficulty in implementing such projects.

A second reason for the chronic shortage of infrastructure has been the reliance on state-owned entities to make the necessary investments in the rail and port systems. Even though the government-owned corporations have been established as for-profit corporations, they tended to be less nimble and entrepreneurial in their decision-making processes than private-sector firms and relied on monopoly profits and fees to compensate for their lack of competitiveness. Over the past decade, Queensland and NSW have privatized both their port and the rail systems, which may lessen in the future the importance of government-infrastructure ownership as a cause of chronic shorts of rail and port infrastructure.

The recent decisions of the Queensland government to first postpone indefinitely the project to implement the Northern Missing Link railway project and then to restart the project based on industry complaints does not bode well for other projects to expand rail and port systems. Due to a lack of commitment from QR to expand Abbot Point from 50 mt to 110 mt, Hancock and Waratah Coal will need to invest in entirely new rail lines and coal terminals if they are to bring their vast Galilee Basin resources to market. For these reasons, the current transport infrastructure constraints are unlikely to be overcome any time soon.

Expansion of Australia's black coal industry is also clouded by the regulatory uncertainty that has been created by the government of Australia's carbon pollution reduction scheme (CPRS) and its 2011 proposal to implement as an interim measure a fixed carbon tax. A second source of investor uncertainty is the proposed mineral resource rent tax (MRRT), which is the successor to the ill-fated resource super profits tax (RSPT). The regulatory uncertainty that these proposals have created continues to slow the decision-making processes of coal mining companies that are interested in developing new coal resources and expanding existing mines and related transport infrastructure in Australia.

Potential coal mining projects most at risk due to regulatory uncertainty are the massive, new steam coal projects planned for the Galilee, Gunnedah, and Surat basins. Only time will tell how the industry will eventually respond. But one can expect a slowdown in project decision making if uncertainty increases about the status of either the CPRS or the MRRT proposals.

The CPRS has received a high level of political scrutiny over the past two years. Domestic sales of steam coal are likely to suffer the greatest adverse impacts if Australia implements the interim fixed carbon tax proposal before moving to a flexible cap and trade program as envisioned under the CPRS. In the short term, the domestic users of steam coal most at risk under either a fixed carbon tax or a flexible CPRS are the owners of brown coal power plants located primarily in Victoria, which have the highest CO₂ emission intensities of all power plants in Australia. However, a number of other brown coal plants, such as the Millmerran and Callide plants in Queensland, may also be adversely affected by these two GHG reduction measures, despite their use of higher efficiency supercritical boiler technology. Nonetheless, the Victoria brown coal plants, due to their age and high CO₂ emission footprints, would be prime candidates for early retirement. Some are already approaching 30 years old and nearing their retirement age. Early retirement of the brown coal plants would not have an immediate adverse effect on the black coal industry. On the contrary such an outcome might lead to higher dispatch for the remaining coal-fired power plants that are fired on higher rank, steam coal.

However, over the long term, the impact on domestic sales of black coal will be substantial, particularly if the price of CO₂ emission permits were allowed to increase significantly over time. The effect would be to discourage the building of new coal-fired power plants and to encourage the development of new power plants based on natural gas and renewable energy resources. As existing black coal power plants are retired, this domestic market would decline over time in much the same way as the shipping and railway industries did in the 1960s.

The domestic power industry is a very significant market for black coal producers in NSW and Queensland. In 2007, Australia's domestic market for steam coal was equal to 39 percent of Australia's total steam coal sales, i.e., domestic plus export sales of steam coal, and 22 percent of its total black coal sales. These figures exclude brown coal, which is not accounted for under

black coal statistics. Therefore, from the perspective of steam coal producers in NSW and Queensland, the CPRS and its fixed carbon tax sibling may deprive them over time of a very significant and lucrative market.

But the bigger concern for Australia's black coal producers must be with their export markets. If the governments of North Asia (China, Japan, Korea, and Taiwan) were also to implement aggressive GHG emission reduction programs that favored alternatives to coal and therefore reduced coal demand growth, the impact on their core business could be devastating. NSW, with its higher proportion of steam to coking coal than for Queensland, will experience greater near-term impacts from any regional carbon tax and/or cap and trade programs. However, over time, the effects would also be strongly felt in Queensland in the form of reduced investments in the Galilee and Surat basins.

5.3 Limits to New Technology as an Tool for Reducing GHG Emissions

The coal and power industries, along with governments around the world, are looking for new technologies to provide the solution to the greenhouse gas and climate change issues. Australia's black coal industry has a long history of applying state-of-the-art mining and exploration technologies and making them work in the Australian context. It can be expected that, given the size of the economic stakes at risk, either Australia's black coal industry or new entities such as CBM extraction companies and UCG production companies will find innovative solutions to the issue of GHG emissions.

Although there is a comforting, if not compelling, story to be told of a resourceful and adaptive industry that finds technical as well as political solutions to its problems, it would be naive to assume that history will automatically repeat itself this time around, especially if one assumes that new technology is the main option for future expansion of Australia's black coal industry. Technologies for removing CO₂ on a post-combustion basis are extremely expensive and their application at new coal-fired power plants will over time lead to a substantial reduction in demand for steam coal by making substitute generation technologies more competitive. Their application will also lead to a reduced "net back price" being paid to Australia's steam coal producers as coal producers will only be able to pass through to its customers a portion of the

additional costs for CCS. To retain customers, coal producers will face one of two alternatives: (1) lower their prices or (2) reduce their production capacity. Most likely, producers will need to do a little bit of both: lower their prices and reduce output. High capital and operating costs of CCS system are not the only constraint. Widespread public opposition to CO₂ storage, even in rural areas, is starting to emerge in both Europe and the United States and is already leading to project cancellations. For example, in Europe the Vattenfall Schwarze Pumpe project (Germany), which was a small 30 MW demonstration of the Oxyfuel process was not able to store the CO₂ underground due to strong local opposition.²⁹² A second example of local opposition derailing a mature CCS project was Shell's Barendrecht CCS project in the Netherlands, which was recently cancelled due to local opposition to sequestering CO₂ deep underground but directly beneath their communities.²⁹³

Assuming that global regulation of GHGs will only increase over time, unless a major technological breakthrough occurs in the area of CCS, the economics of burning coal in its current solid, high-carbon content form will undoubtedly become less economically attractive over the next two decades in regions that adopt regulation. Betting on a major breakthrough in either pre- or post-combustion carbon capture technology appears to require governments worldwide to assume an extremely high level of technical and economic risk.

Those technologies that offer the greatest near-term application—CBM and UCG—will most likely lead to a significant diversification of Australia's black coal industry from one that is currently focused on extracting and selling high carbon solid fuels to one that also extracts and markets gaseous and perhaps liquid fuels with substantially reduced carbon contents.

Both UCG and CBM producers have the benefit of producing their energy products from coal resources that are at depths that are uneconomic to mine via underground mining methods. This

²⁹² Stina Rydberg, "Experience from Schwarze Pumpe" (Power Point presentation dated 2010-11-11 and available online at <http://www.vtt.fi/files/projects/ccsfinland/seminaari2010/09-rydberg.pdf>)

²⁹³ Carbon Capture Journal "Shell Barendrecht project cancelled" (article dated November 05 2010 and available at <http://www.carboncapturejournal.com/displaynews.php?NewsID=676>); Also see: Fred Pals, "Barendrecht's Stand Up to Shell's Plan to Bury Co2", Bloomberg, April 2009 (<http://www.bloomberg.com/apps/news?pid=newsarchive&sid=apxoWWj1cCh0>) Richard, I would appreciate your kind offer of help to find a few other appropriate citations

feature of both technologies will limit competition between traditional coal producers and CBM and UCG producers. Except for the water disposal issues created by CBM production and the CO₂ emissions from the UCG process, both technologies have a very small aboveground footprint when compared with open-cut mining methods and their visual impacts are minimal. From the standpoint of resource conservation and land use environmental impacts, both technologies appear to offer significant environmental advantages over traditional production of solid fuels.

UCG allows the in situ conversion of solid coal into a synthetic gas that can be used for power production or the production of petrochemicals and, in particular, ammonia-based petrochemical products such as fertilizers and explosives. When compared with CBM or even the most efficient open-cut mining methods, UCG allows much greater densities of energy extraction from underground coal resources. Finally, it maintains the ash and unburned carbon and other residues deep below ground.

However, for UCG to be successful, improvements appear necessary in two supporting technologies:

- (a) Carbon capture and sequestration: In situ gasification produces the same level of CO₂ as a coal-fired power plant but at much higher levels of concentration in the gas stream. Ironically, UCG may be the catalyst for development of a small but economically viable CCS industry, which relies on gas streams containing CO₂ concentrations of 50 percent or more, not the highly dilute CO₂ concentrations of less than 15 percent found in most power plant flue gases. In order for that to happen, improved technologies for capturing the highly concentrated CO₂ as it exits with the syngas from the extraction well are urgently required.
- (b) Air separation plants: Oxygen-blown UCG has a number of advantages over the use of air. It allows the production of higher concentrations of CO₂, H₂ and CH₄, and less CO in the production gas. It also minimizes the formation of NO_x during the gasification process. But existing air separation technology is capital intensive and expensive to operate. If significant improvements can be made to the efficiency of such plants and in

particular to the compressors used to extract oxygen from the air, this breakthrough could tip the balance toward UCG processes that use oxygen instead of air to produce their energy products.

UCG's success will also be dependent on government regulations that encourage, if not require, "peaceful coexistence" between CBM and UCG proponents.

In the case of CBM and Australia, a vibrant CBM industry exists today, which, over the next two decades, should lead to a significant reduction in the carbon footprint of Australia's power sector. The CBM extraction industry of Queensland is already providing competitively priced methane as an alternative to solid steam coal. Since methane has 50 percent less carbon than methane, over time, if Australia's existing coal-fired plants are retired and replaced by new combined cycle gas turbine (CCGT) power plants fired on CBM, this replacement program would lead to a significant and progressive reduction in the carbon emissions of Australia's power sector. This coal-to-CBM transition is already occurring in the states of Queensland and NSW. Substituting CBM-fired plants for new coal-fired plants is likely to lead to the same reduction in GHG emissions as a CCS program that requires a 50 percent CO₂ removal target for each newly built power plant—but at a far lower cost and risk of failure.

5.4 Alternative Futures

Given this uncertain industry outlook and in particular the uncertainties concerning cap-and-trade CO₂ emission programs and new technology, it is not possible to suggest a single future for Australia's black coal industry. Instead, Australia's black coal industry faces the prospect of confronting at least one of two opposing futures:

1. A "business as usual" (BAU) scenario, which assumes (a) weak actions by Asian governments to reduce GHG emissions, (b) only minor improvements in CCS, UCG, and other technologies for reducing GHG emissions, and (c) the governments of NSW and Queensland continuing to play their traditional roles of supplying transportation infrastructure to the black coal industry

2. An aggressive GHG reduction scenario that assumes strong GHG emissions standards and implementation by Asian governments of cap-and-trade policies coupled with significant technological breakthroughs for CSS and UCG

Under the BAU scenario, one can expect coal producers to continue delivering energy from coal almost exclusively in solid form using existing rail and port networks expanded to meet their increased production. CBM and UCG projects will be developed at a much slower pace than would occur under an aggressive GHG reduction scenario. But growth in the production of CBM would continue and further development of the UCG industry should also continue, due to the significantly higher cash costs for delivering the resources of the Galilee, Gunnedah, and Surat basins to their end-use markets in solid form.

In response to these price signals, albeit weaker than the signals from an aggressive GHG reduction scenario, one would still expect power plant owners to choose to build new, CBM-fired, CCGT plants rather than new, coal-fired, power plants. Over time (20 to 30 years) there should be a more significant shift to gas-fired CCGT plants, as coal-fired plants are retired and new CCGT plants are fired on either CBM or UCG-derived syngas. However, the lifetimes of coal-fired power plants are at a minimum 40 years, with 50- to 70-year operating lives not uncommon. The potential for early retirement of black coal-fired power plants in Queensland and NSW is not very strong under a BAU scenario. Victoria's brown coal power plants are a different matter. Given their age, they offer the strongest prospects for early retirement under a BAU scenario and replacement with gas-fired CCGT plants located either in Victoria or in other states with power transmitted to Victoria.

But the power sector transition would be very slow. It is difficult to imagine a case where a significant reduction in CO_{2e} emissions from the coal-fired power sector would ever occur under a BAU scenario by 2030. Instead the domestic use of steam coal in Australia would be expected to maintain its current use level (in million tonnes) for the foreseeable future.

Under the aggressive GHG reduction scenario, governments of North Asia, i.e., Japan, Korea, and Taiwan, and the Australian government are assumed to enter into an international agreement

to reduce GHG emissions in line with previous UN Framework Convention on Climate Change (UNFCCC) recommendations:

- A 25 percent to 30 percent reduction in 2020 CO_{2e} emissions from 1990 levels
- Even greater reductions by 2050

The impacts on the steam coal portion of Australia's black coal industry will depend largely on technology. If "hoped-for" reductions in cost and improvements in efficiency of CCS systems occur over the next decade, power companies and other large coal consumers are expected to adopt these systems for new plants and possible existing plants. Under this case, one would expect some reduction in steam coal usage due to expedited retirement of coal-fired power plants and their replacement by gas-fired power plants and to a small extent by power plants that rely on renewable energy resources. The outcome will be dependent on the magnitude of the CCS cost reductions and efficiency improvements in competing technologies such as CBM, UCG, and renewable energy resources.

However, it is unlikely that cost reductions and improvements to CCS systems will be sufficient to maintain the status quo over the next decade. If aggressive GHG reduction standards are adopted in Australia and the rest of the Asia-Pacific region, it is likely that Australia's steam coal industry will diversify from one that is based on the extraction and marketing of solid, high-carbon fuels to a two-tiered industry consisting of a competitive, slow-growing solid fuel segment and a fast-growing liquid and gaseous fuel segment, which will rely on the extraction of gaseous and liquid fuels from coal resources that are at depths that are uneconomic to extract as solid fuels. Under this scenario, the CBM industry located in NSW and Queensland will continue to grow and prosper. Coupled with a still-to-be-created UCG industry, these two new industry segments might offer an alternative pathway for the industry's growth and prosperity.

There will of course be winners and losers, with those companies adhering to the old methods of extracting coal over time losing their current growth premiums and perhaps becoming declining industries. Examples of this happening in the past include the town gas industry and those die-hard adherents to ships and railway locomotives running on coal. The choices may appear

exceptionally challenging if not stark; but Australia's black coal industry has been here before. What remains to be seen is whether it can repeat the development miracle of the past 60 years in a brave new world of carbon emission limits and with new technology choices that are much less proven than the technologies considered for adoption immediately after WWII.

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