Regional Minerals Program

Energy for Minerals Development in the South West Coast Region of Western Australia

Executive Summary

ENERGY FOR MINERALS DEVELOPMENT
IN THE SOUTH WEST COAST REGION OF WESTERN AUSTRALIA
EXECUTIVE SUMMARY

December 2004

Prepared for Western Australian Department of Industry and Resources
Under the Australian Government's Regional Minerals Program

Prepared by Sleeman Consulting in alliance with Goodall Business and Resource Management

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Photo Credits Front Cover: 1. Coal haulpak; 2. Alcoa's Bunbury alumina loadout facility; 3. Gas flame 4. Dampier to Bunbury natural gas pipeline; 5. Coal mine near Collie; 6. Bauxite ore/aluminium oxide; 7. Hovea Plant - photo courtesy of Arc Energy; 8. Titanium Dioxide plant

1 BACKGROUND

This Study was commissioned by the Western Australian Department of Industry and Resources and has been undertaken within the framework of the Australian Government's *Regional Minerals Program,* administered by the Department of Industry, Tourism and Resources.

The ultimate objective of the Study is to provide information to attract private sector investment into Western Australia to stimulate development of the State's mineral and petroleum resources for the benefit of investors, the State and Australia. The focus of the Study was the south west coast region of Western Australia which extended from Port Gregory (north of Geraldton) to Albany, as depicted in Figure 1. The study region comprised the regional areas of the Mid West, Perth Metro, Peel, South West and part of the Great Southern Region and had a total area of the order of 175,000 square kilometres, which is just over half the size of Italy. The region represents about 5% of the Western Australian land mass and is home to 90% of the State's population.

The Study was thematic in nature. It investigated material and information of relevance to energy and minerals development in the south west coast region of Western Australia in order to identify the most significant issues and priorities for ongoing attention. In particular, the following activities were completed.

- The mineral resources of the south west coast region were reviewed, with regard for quality, size and production costs to identify development opportunities and target prices of energy required to achieve project viability. The mineral resources of the study region represent approximately 10% of the State's mineral wealth and have a combined value, estimated by the Geological Survey Division of the Department of Industry and Resources, in excess of $660 billion.
- Prospects for supply of additional energy and/or electricity to the south west coast region were reviewed and estimates of the availability and price of energy were developed.

Figure 1: South West Coast Study Region

- The projected energy requirements were compared to the predicted availability and cost of energy in order to identify likely integrated development scenarios. The economic impacts of the identified scenarios were investigated using computable general equilibrium modelling techniques.
- Issues related to the development of minerals opportunities or to the supply of energy to them were reviewed and, where appropriate, recommended actions were formulated.

A comprehensive Study Report is available and can be found at www.industry.gov.au/rmp or at www.doir.wa.gov.au

Alcoa's Bunbury alumina loadout facility

2 REVIEW OF MINERALS SECTOR

2.1 Bauxite, Alumina and Aluminium

a) Alumina Production

The south west coast region was the world's largest single producer of alumina during 2003. As international demand for alumina grows, it is anticipated the production capacity of the region's low cost refineries will be progressively expanded. By 2010, the alumina production capacity of the south west coast region is projected to reach 15.7 Mtpa, giving rise to a requirement for 143 TJ/d of additional energy.

Known reserves of bauxite are sufficient to support operations at current and planned production rates for over thirty years.

b) Fused Alumina

A small quantity of locally produced alumina is used in the value-added production of 21,000 tpa of high-quality, white fused alumina for high performance abrasive and refractory uses. Australian Fused Materials Pty Ltd (AFM) uses around 4.7 MW of electricity in this process.

The fused alumina market is extremely competitive with Chinese producers dominant during the late 1990's and early 2000's. Recent power shortages in China have lead to reduced international availability of fused alumina and potential may exist for expansion of AFM's operation. An expansion decision will be largely market driven.

c) Aluminium

Over the period 2003 to 2007 world demand for aluminium is projected to increase on average by more than 1.0 Mtpa each year. To satisfy this demand growth it is expected that some 2 Mtpa of capacity, equivalent to the development of 1.5 new aluminium production pot-lines per annum, will need to be developed outside of China over this period.

Over the past seven years, the average cost of electricity to new aluminium smelters has been estimated to be US$13.20/MWh (1.9 c/kWh, Australian). However, the availability of low-cost electricity from traditional sources is declining.

For a smelter development to be attractive in the south west coast region it will need to be capable of producing aluminium at a cost level that is in the bottom quartile of aluminium production costs. To achieve this, labour and capital costs and electricity prices will need to be competitive with alternative locations. The target electricity price to achieve international competitiveness is reported to be of the order of 2.6 c/kWh.

Modern Aluminium smelters have a production rate of 350,000 tpa per pot-line with two pot-lines being required in order to achieve internationally competitive production costs. The energy requirement per pot-line is around 500 MW which, in turn, requires some 60 TJ/d of gas if high levels of efficiency are achieved through electricity cogeneration. Alcoa World Alumina Australia (Alcoa) is reportedly able to achieve this level of efficiency.

2.2 Iron Ore

Western Australia is a major supplier of iron ore to international markets, with the majority of production being from the Pilbara region. However, strong demand for seaborne iron ore has created opportunities for development of a number of iron ore deposits within the study region.

As depicted in Table 1, there are a number of iron ore deposits in or just outside the boundaries of the study region. Several companies are working to develop these deposits and the first shipment of iron ore through Geraldton for thirty years was made in February 2004 when 38,000 tonnes was shipped to China from Mt Gibson Iron Limited's Tallering Peak hematite mine. Exports of hematite by Mt Gibson and Midwest Corporation Limited are projected to reach 5.2 Mtpa by 2006.

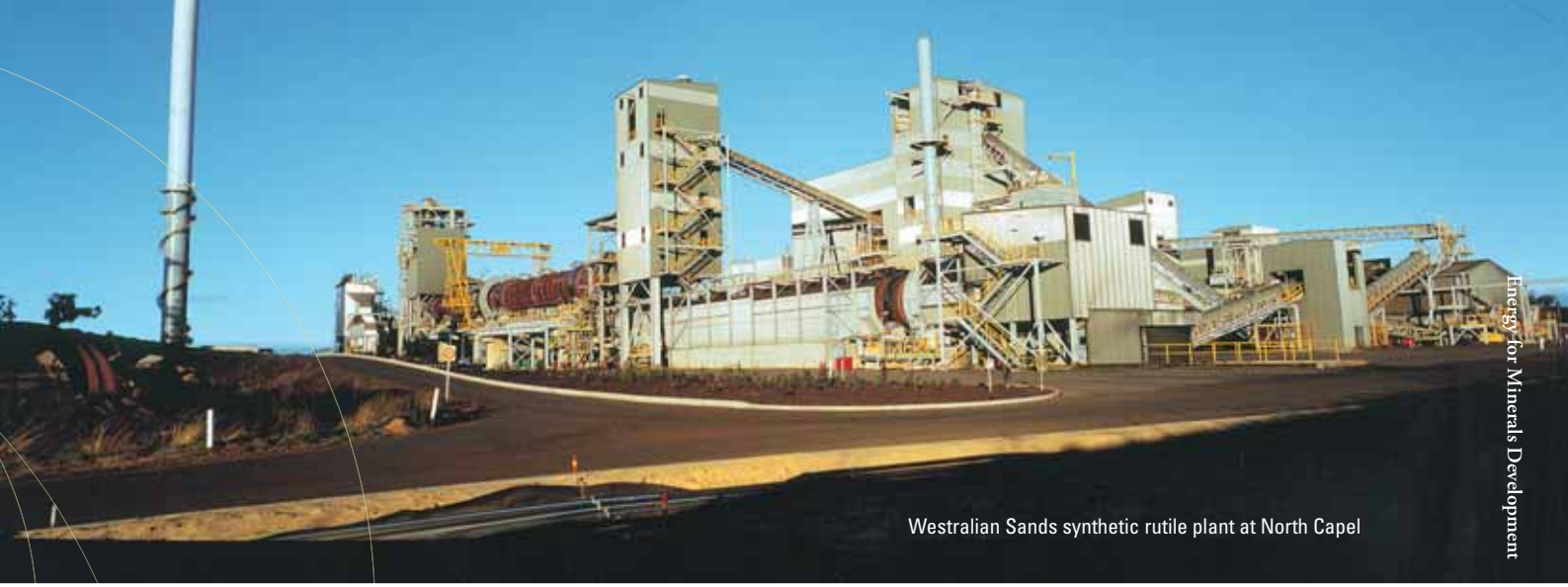
Further iron ore related expansion opportunities in the study region are based around the large magnetite deposits of the Mid West Region and Great Southern regions. These deposits can be developed for export either as a magnetite concentrate or in beneficiated form (as pellets).

Table 1: Iron Ore Resources in the Study Region

Company and Deposit	Reserves		Measured and Indicated	
	Mt	Grade %Fe	Mt	Grade %Fe
Mt Gibson Iron Limited				
Tallering Peak T4 & T5			20.5	63.68
Extension Hill			10.7	63.8 – 58.2
Iron Hill			20.7	63.8 – 58.2
Midwest Corporation Limited				
Koolanooka	405	34.9	430	35
Blue Hills	0.7	60.4	1.2	60.3
Weld Range	129	55.6	152	56.03
Grange Resources Limited				
Southdown			53.6	30.3

Table 2: Location of Major Mines and Processing Facilities

Company	Major Mine	Dry Plant	Synthetic Rutile	Titanium Pigment
Iluka Resources Limited	Eneabba, Capel & Geraldton	Capel	Capel, Geraldton	–
TiWest Joint Venture	Cooljarloo	Chandala (Muchea)	Chandala (Muchea)	Kwinana
Cable Sands (WA) Pty Ltd	Jandardup	Bunbury	–	–
Doral Mineral Sands Pty Ltd	Dangardup	Bunbury	–	–
Millennium Inorganic Chemicals Inc	–	–	–	Bunbury



Westralian Sands synthetic rutile plant at North Capel

Due to the complexity of processing required, the capital cost of magnetite processing facilities is significantly higher than for hematite production. Feasibility studies are underway for production of magnetite concentrate in 2.5 Mtpa modules and for 5 Mtpa concentrator and pellet plants. The electricity demand for a 2.5 Mtpa magnetite concentrate plant is estimated at 20 MW. At current export prices, electricity is not a major cost component and magnetite production would be feasible at electricity prices of 6 to 7 c/kWh.

The total capital cost of a 5 Mtpa magnetite mine, concentrator and pellet plant is estimated at $540 million. The energy requirement for such a facility is estimated to be up to 1.0 GJ per tonne of pellets. On the basis of current pellet pricing, indications are that a project of this nature would be viable with a gas price of $3.00/GJ to $3.50/GJ.

The potential also exists for production of metallurgical pig-iron from hematite, magnetite and/or iron-rich synthetic rutile tailings. Both gas and coal based technologies are available. To be internationally competitive, it is estimated that an operating cost below US$110 per tonne of pig-iron is necessary. In turn, it is estimated a power price in the range of 4 c/kWh would be required for pig-iron production in the south west coast region to be viable. Energy would need to be available at prices of not more than $1.50/GJ for coal or $2.80/GJ for gas in order for a pig-iron development in the south west coast region to be viable.

The HIsmelt metallurgical pig-iron plant at Kwinana is scheduled to commence operation early in 2005 and will produce a premium grade hot metal from iron ore fines and non-coking coals. The first stage of the HIsmelt plant will have a production capacity of 0.8 Mtpa. The intention is to increase this to 1.5 to 1.6 Mtpa after the process has been operated for two to three years and any initial problems have been addressed. To meet process requirements coal is to be imported from Queensland. The prospect may exist for Collie coal to be upgraded to meet HIsmelt requirements and to displace imported coal. HIsmelt also uses an average of around 4.95 TJd of gas and will export a small amount of electricity to the grid.

2.3 Silicon

Simcoa Operations Pty Ltd produces 32,000 tpa of high grade silicon metal at its Kemerton facility, 17 kilometres north of Bunbury. Quartz reserves are sufficient for twenty years of operation, and there are significant additional resources that have not been drilled. Electricity demand is estimated at 11 MWh/tonne with a total site demand of 45MW.

World demand for silicon metal is increasing at an estimated rate of 45,000 tpa of which 55% is in the high end chemical sector of the market serviced by Simcoa. There is reasonable scope for expansion by Simcoa, with the key factors in an expansion decision being the availability of electricity at a price of the order of 4.0 c/kWh, and the ability to market silicon product.

Expansion could be either one or two furnaces with potential capacity of 20,000 tpa per furnace. This would result in an increase in power demand to 75 to 80 MW to bring total production to 72,000 tpa of silicon metal.

2.4 Mineral Sands

a) Mineral Sands Production

The mineral sands industry of the south west coast region comprises a small number of producers with operations as set out in Table 2.

The major mineral sands ore bodies at Capel, Eneabba and Cooljarloo have been mined for 48, 32 and 15 years respectively and are significantly depleted.

While new projects may commence in the next 10 years, in view of reserves limitations, it is unlikely that this will result in major expansions of mineral sands production levels from the study region.

A pile of zircon bearing mineral sands at Iluka's operation at Eneabba

b) Synthetic Rutile Production

Synthetic Rutile (SR) is produced using the modified Becher process by both Iluka Resources Limited (Iluka), at Capel and Geraldton, and the TiWest Joint Venture (TiWest) at Chandala. The process uses coal as both a reductant and a heat source. Iluka's Capel plant recovers excess heat to generate 7.5 MW of electricity, which is just over half of its requirement.

Production of 691 kt for 2002/03 was comprised as shown in Table 3.

Over the next 10 years, as the availability of ilmenite suitable for use in the Becher process declines, it may be necessary to import ilmenite as feed to maintain the SR operations at capacity. In the near term it is anticipated that any production increases will be due to process changes or debottlenecking of existing facilities. The potential may exist for a more significant (up to 20%) increase in production capacity through the use of briquettes or coal char manufactured from Collie coal. Present coal consumption is around 0.65 tonnes per tonne of SR.

Iluka is currently carrying out studies to determine the location for a new generation SR process based on gas rather than coal. While sites in the study region are under consideration, locations close to the Murray Basin mineral sands deposits or in other countries offering significant tax benefits, may be favoured

Table 3: Synthetic Rutile Production 2002/03

Company	Location	Production (kt)
Iluka	Geraldton	215
	Capel	256
TiWest	Chandala	220
Total		691

c) Titanium Pigment

TiWest and Millennium Inorganic Chemicals Inc both operate chloride route pigment plants within the south west coast region. In these plants, synthetic rutile is combined with petroleum coke and chlorine to produce titanium tetrachloride that is purified and oxidised to produce titanium dioxide. Based on an average price for Australian pigment exports to Asia in 2003 of US$1,730 ($2,470), the value of pigment produced within the study region is $494 million.

Major costs in the process are the synthetic rutile feed, wages and salaries, other chemicals and maintenance. Energy, in the form of natural gas (at 5 GJ/t) and electricity (at 0.5 MWh/t), represents less than 10% of operating costs. Consequently, expansions will take place at prevailing levels of energy price.

d) Zirconia Based Opportunities

Zircon flour, zirconia and fused zirconia are all produced in Western Australia. These are all energy intensive processes and expansion decisions are dependent on competitive power and gas costs. However, current overall power consumption (less than 10 MW) is relatively small compared to major industrial projects.

e) Titanium Metal

Some 70,000 to 80,000 tpa of titanium sponge is produced world-wide each year using the electricity-intensive Kroll process. While prices in 2003 were US$7.28/kg, which was the lowest level for ten years, with demand growth in aerospace, armour, industrial and consumer markets, opportunities are now emerging for start-up of mothballed, or installation of new, production capacity.

There are several companies currently working on new titanium metal production processes that are significantly less electricity-intensive than the Kroll process. The target of these processes is to halve production costs so that titanium use will be competitive with other light metals. There is the potential to establish a titanium metal pilot plant adjacent to existing titanium pigment operations in the south west coast region over the next two to three years.

Mined Bauxite, Boddington south-east of Perth

2.5 Nickel and Cobalt

While there are no operating nickel mines in the south west coast region and no known reserves, nickel refining operations are carried out at Kwinana. WMC Resources Limited's Kwinana refinery processes nickel matte from the Kalgoorlie Nickel Smelter to produce high quality nickel briquettes and nickel powder, and is one of the world's lowest cost producers. The refinery currently consumes around 3,300 TJpa of gas (for steam raising and as a reductant) and 15 MW of electricity.

The capacity of the refinery will be increased from 67,000 to 70,000 tpa by the end of 2004, making it the world's third largest refinery. It is expected that ongoing expansion of the Kwinana refinery will take place, with production reaching 80,000 tpa over the next three to five years, and with potential for further expansion to 100,000 tpa of refined nickel within the next 10 years. These expansions will proceed at present energy prices.

2.6 Tantalum, Spodumene and Tin

Sons of Gwalia Ltd (SOG) operates one of the world's largest sources of tantalum at Greenbushes. Lithium minerals (spodumene) and tin are also produced as a byproduct of tantalum production. Although SOG was placed into administration in August 2004, the Greenbushes project is expected to continue to operate.

There has been recent strong growth of demand for tantalum, driven by requirements in the electronics and turbine markets and prices have returned to previous highs of US$40-50/lb. With SOG supplying over 50% of global demand it is considered likely to expand production in order to stabilise the market and discourage new entrants. However, with production contracted to major US and European consumers it is unlikely that any downstream processing will be carried out in Australia.

While SOG has the major hard rock deposits of lithium in the world, its leadership in the world market was displaced in 1997/98 when Chilean producers reduced prices from $4.50/kg to $2.10/kg for brine based lithium, which is the preferred feed for lithium carbonate production. SOG has suspended production from its lithium carbonate plant and the majority of spodumene produced now goes into the glass and ceramic markets. On this basis the potential for further processing in Western Australia is considered to be low.

2.7 Ferro Alloys

Ferro alloys are alloys of iron that contain sufficient concentrations of one or more chemical or metallic elements to modify the properties to which they are added, mainly steel. Ferro-silicon is the only product that is considered to have significant potential for development in the south west coast region.

Chinese production of ferro-silicon, which accounts for over 40% or 5 Mtpa of world production, has declined over the past twelve months owing to power shortages while rapid increases in steel production have led to increased levels of demand and price. The development of a 50,000 tpa ferro-silicon plant would require capital of approximately $80 million and would have an electricity demand of 8 MWh per tonne of product. At an electricity price of less than 4.0 c/kWh a ferro-silicon production cost of approximately $700/t might be achieved. This could make such a development viable.

2.8 Other Minerals

While a wide range of other minerals are produced in the study region, they are either minor energy consumers or have little potential for energy based downstream processing.

Coal Haulpak

3 REVIEW OF ENERGY AVAILABILITY AND COST

3.1 Coal

a) Industry Overview

There are numerous identified coalfields within the south west coast region of Western Australia, including the State's only producing coalfields in the Collie Basin. Collie Basin mining activities are carried out by the Griffin Coal Mining Company Pty Limited (Griffin) and by Wesfarmers Premier Coal Limited (Premier). Mining is by means of open-cut, truck and shovel methods.

Griffin and Premier have roughly equal shares of the present market for Collie Basin coal, although Griffin supplies a greater portion of the smaller (non-Western Power Corporation) customers. Indications are that, at present production levels, prevailing run-of-mine coal prices average around $45/t ($2.25/GJ).

b) Northern Perth Basin Development

The coal resource of the northern Perth Basin represents a significant prospective energy source. Development of the northern Perth Basin coal reserves could be particularly attractive as an energy source for coal-based minerals developments to the north of Perth. Freight costs from the existing coal mining operations of Collie to locations north of Perth would otherwise add of the order of $1.00/GJ to $2.00/GJ to the delivered cost of coal.

Aviva Corporation Ltd is promoting development of its 'Central West' coal resource, which lies within existing mining lease areas at Eneabba. The unconsolidated nature of the overburden in the Eneabba area means that a dozer-trap operation (whereby overburden is pushed by bulldozer into a truck loading facility) may have application. Coal production costs as low as $23/t ($1.35/GJ) might be achievable. The cost and availability of Eneabba coal are illustrated in Figure 2. The cross-hatched area in Figure 2 represents possible production, dependent upon the realised capacity of the dozer-trap.

c) Collie Basin Expansion

The potential exists for Griffin and Premier to achieve lower average coal production costs with increased coal production.

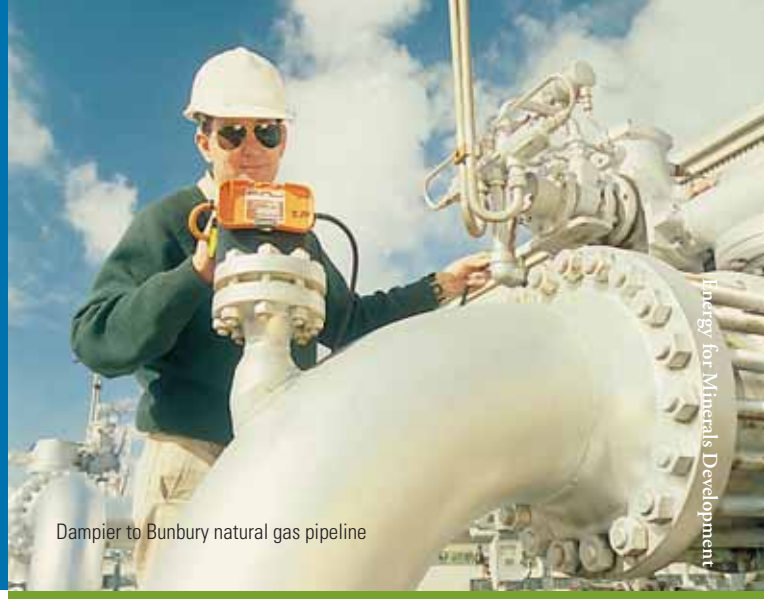
The overburden handling capability of Premier's existing equipment fleet could allow the production of some 5 Mtpa of coal. On the basis of Australian coal industry indicative information, there would appear to be scope, through increased production, for Premier to produce coal at a cost of the order of $30/t ($1.50/GJ).

With an increase in coal production quantities the potential could exist for use of a dragline as the primary means of overburden removal at Griffin's Ewington operation. The introduction of draglines has not been possible historically owing to a combination of factors including low coal tonnages and, in particular, the depth, moisture content and geometry of the Muja open-cut. The introduction of a dragline would reduce the cost of overburden removal and, on the basis of Australian coal industry indicative information, Griffin should also be able to produce coal at or below a cost of the order of $30/t ($1.50/GJ).

Recognising the magnitude of benefits that are estimated to be achievable through increase in the production of coal, initiatives that might contribute to the achievement of scale economies (for example, integration of operations, possibly using a joint venture model) need to be pursued.

Premier is investigating prospects for production of coal char and has committed to the development of a 50,000 tpa demonstration plant to prove the commerciality of the product. If successful, 1.6 Mtpa of Collie coal might be used to displace imported coal from the HIsmelt operation. Griffin is currently piloting a process for briquette production with a key, initial target market being the synthetic rutile operations where, through use of briquettes, there may be scope to achieve increased synthetic rutile production.

Overall, the estimated cost and availability of additional coal from the Collie Basin is as illustrated in Figure 3. Where customers are located away from the mine it is necessary to add freight costs to the depicted values to determine delivered coal costs.



Dampier to Bunbury natural gas pipeline

3.2 Gas

a) Overview

Western Australia is well endowed with natural gas, with in excess of 70% of Australia's commercial gas reserves being located within sedimentary basins off the northwest coast of the State. The availability of gas at internationally competitive prices has stimulated growth of the Western Australian gas market, particularly though use of gas in minerals projects. At the same time, development of remote gas production and pipeline infrastructure has been underpinned through the foundation gas purchase commitments of large minerals projects.

Ongoing development of gas reserves will need to take place in a timely manner to ensure that gas continues to be available in quantities to meet existing and expanded domestic market requirements. The most likely sources of gas for future supply are located in the Perth and Carnarvon Basins. Carnarvon Basin sources include ongoing development of the North West Shelf and Varanus Island projects, as well as new developments (eg, Gorgon).

b) Prospective Sources of Gas Supply

Perth Basin

While all available gas reserves of the Perth Basin are presently contractually committed, prospects for further discoveries of gas within the Basin are good. Based upon the extent of various Perth Basin prospects, backed by experience to date, it would appear that new discoveries of gas in the Perth Basin may be in the 10 to 15 PJ size range. Even though a number of new discoveries could be made, the size and proximity to existing infrastructure and markets means that this gas will inevitably be used to compete on a price-taking basis in the south west gas market, rather than to stimulate new developments requiring lower gas prices. For example, Figure 4 shows that a large portion of the forecast south west coast gas market is not presently contracted for supply in the longer term. To illustrate the extent of the uncontracted market the shaded area in the figure represents a gas quantity of approximately 1 exajoule (EJ, roughly equivalent to 1 TCF), which is double the initial reserves of the Dongara gasfield (to date the biggest commercial discovery in the Perth Basin). The large change that occurs in 2020 reflects the expiry of Alcoa's and Alinta Limited's gas purchase contracts.

Figure 2: Cost and Availability of Eneabba Coal

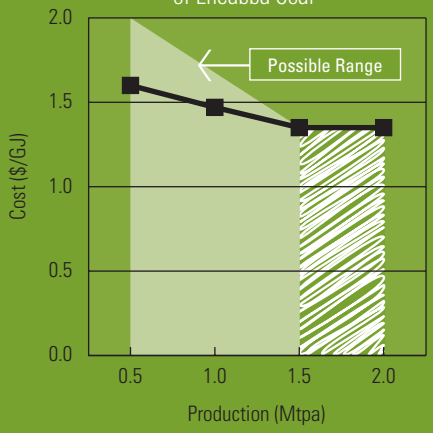


Figure 3: Availability and Cost of Additional Collie Basin Coal

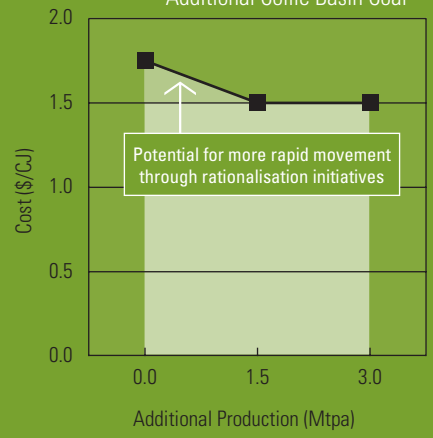
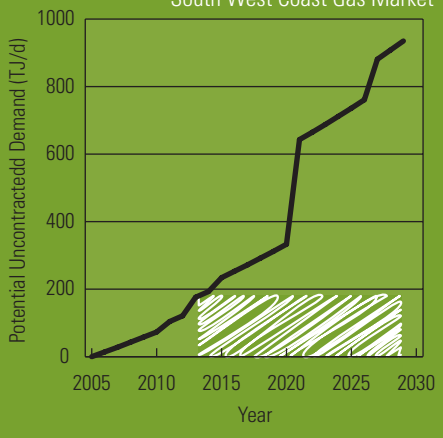


Figure 4: Estimated Uncontracted South West Coast Gas Market



Hovea oil field production facility - Arc Energy

From a practical commercial perspective, marketing of Perth Basin gas on a price setting basis would probably only be considered if the availability of gas is materially in excess of that which might be readily sold into the existing market. In order of magnitude terms, this would require several exajoules of gas to be proven. Although the probability that discoveries of this size might be made is considered to be low, it is not to be ignored. For example, several exajoules of gas are presently known to exist in tight formations within the Perth Basin and technological developments may allow their commercialisation.

The potential may also exist for production of coal seam methane from the Vasse Shelf coal resource, which extends from Busselton to Augusta and which has a rank and depth consistent with the requirements for coal seam methane.

It is desirable that further exploration in the Perth Basin, and continued pursuit of the Whicher Range natural gas and Vasse coal seam methane initiatives, be encouraged.

North West Shelf Project

The North West Shelf (NWS) project is the State's largest supplier of gas. It produces gas from reservoirs located around 130 km off the coast of WA, to the northwest of Karratha, and routinely supplies up to 600 TJ/d of gas for domestic market use throughout the State.

Subject to ongoing development of gas reserves, gas should be available from the NWS Project for supply to existing markets or to new minerals developments in the south west coast region. The extent to which gas is available for new minerals developments in the south west coast region may however be dependent upon the value of gas in domestic markets relative to its value in export markets (although near-term domestic sales are likely to be attractive in comparison with longer-term LNG sales).

If significant alternative sources of gas supply are not developed a tightening of gas supply to domestic markets could result, leading to upward pressure on gas prices.

Gasfields Surrounding Varanus Island

Processing and compression of gas from the Harriet, East Spar, John Brookes and a number of smaller fields takes place on Varanus Island. Gas is presently available from these sources for supply under new or extended gas sales arrangements.

However, it is unlikely that it will be offered at prices that would facilitate new minerals developments in the south west coast region since increased water depths and/or distances from Varanus Island are expected to lead to increased reservoir development costs and, in the short to medium term, there will be numerous opportunities to contract for supply of gas to existing users, as depicted in Figure 4.

It is estimated gas prices tending towards $2.50/GJ could be sought in the medium term as development of more remote reserves of gas becomes necessary.

Gorgon Project

The Gorgon gasfield is one of the largest discovered in Australia. The Gorgon and surrounding gasfields contain probable resources in excess of 55 EJ. Development of the gasfields is dependent upon commitments being secured for the sale of LNG in quantities to achieve commerciality. There are reasonable prospects that a sufficient level of LNG sales commitments will be achieved and that the Gorgon project may commence production around 2010.

A go-ahead of the Gorgon project will pave the way for supply of gas for domestic purposes, and 2,000 PJ (ie, 2 EJ) of gas has been earmarked for this purpose. The Gorgon project proponents are required (under the terms of the State Agreement) to actively seek domestic markets. Expansion of LNG sales will not be allowed until domestic sales are established (or their lack of viability demonstrated).

Subject to a sufficient quantity of gas being contracted for sale, it is estimated there may be an opportunity for a large, base-load customer to procure gas at a price of the order of $1.85/GJ. This is not a price that would be generally available (ie, to the wider gas market).

Other Carnarvon Basin Sources

Although there are numerous, other prospective sources of gas within the Carnarvon Basin it is unlikely, for the following reasons, that gas would be available from them at prices below present market levels (estimated to be of the order of $2.10/GJ to $2.30/GJ, excluding transmission costs).

Whicher Range
in the Perth Basin

- Unlike Gorgon, other major gas resources of the Carnarvon Basin may not have the level of gas reserves that would justify complementary sales of gas to domestic markets.
- The prospective use of floating production, storage and offtake (FPSO) techniques may contribute to project economics, but would mean gas is not available for onshore use.
- Development of gas resources for delivery through existing infrastructure, such as that of the North West Shelf project, may in some cases be an option but it is not envisaged this will allow delivery of gas at prices below prevailing levels.

There are no development prospects that presently afford the opportunity to procure gas at less than prevailing or predicted price levels.

Browse and Bonaparte Basins

The gas reserves of the Browse and Bonaparte Basins may be sufficient to support further development of LNG export markets or might in some cases be developable to supply onshore markets (eg, development of Blacktip to supply gas to Gove Alumina in the Northern Territory). However, owing to the remote location of these resources, gas is unlikely to be available from them at prices that are competitive with gas from Carnarvon Basin sources.

c) Gas Transmission

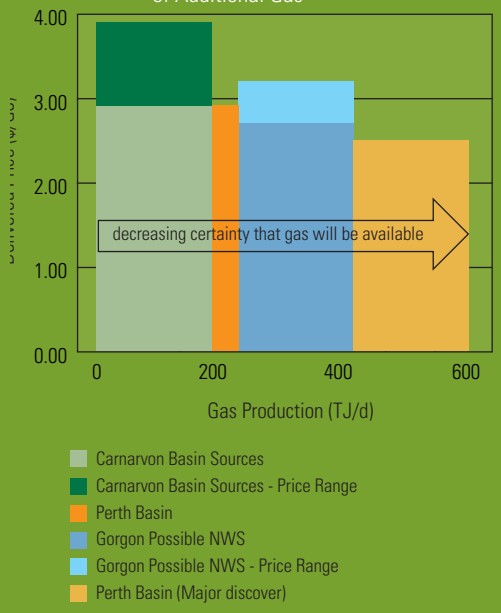
The major prospective near-term source of gas for use in mineral related developments in the south west coast region is the Carnarvon Basin. To deliver gas from Carnarvon Basin projects to the south west coast region expansion of the capacity of the Dampier to Bunbury gas pipeline (DBNGP), or bypass of it, will be required. The economics of expanding the capacity of the pipeline are attractive and it is important that the benefits of expansion economies flow through to tariffs for use of the pipeline.

d) Potential Delivered Gas Costs

The forecast availability and price of gas for use in the south west coast region are illustrated in Figure 6.

Figure 5: Whicher Range Gas and Vasse CSM Prospects

Figure 6: Availability and Delivered Cost of Additional Gas



Electricity power lines

3.3 Electricity

The south west coast region is serviced by an interconnected electricity system, referred to as the South West Interconnected System (SWIS). All large users of electricity have open-access to the SWIS, allowing them to purchase their requirements from electricity generators of their choice.

a) Opportunities for Expansion

Generation of electricity as part of Western Power Corporation's integrated system has potential advantages in that the overall capacity factor of the system will be improved and a whole-of-system approach can be adopted to determine optimal power station expansion and dispatch arrangements.

The estimated cost of generating additional electricity to meet small to medium load increments is around 3.6 c/kWh, excluding transmission costs and margin. Significantly, if the incremental load to be supplied is interruptible this figure might then fall to around 2.8 c/kWh.

Alternatively, stand-alone electricity generation facilities could be developed on, or adjacent to, the site of the electrical load to be supplied or could be developed at a separate location, in which case electricity transmission costs will also be incurred. In either case, if the electrical load is not interruptible there is also a need to take back-up generation requirements into account.

On the basis of potential coal and gas price levels, electricity costs of around 4.0 c/kWh, +/- 0.3 c/kWh, would appear to be achievable using conventional (coal based steam or gas combined cycle) technologies to generate electricity for large, base loads. This figure does not include transmission costs or back-up/spinning reserve charges, if applicable.

The potential also exists for cogeneration of electricity, particularly at Alcoa alumina refineries in the southwest of the State. It is estimated that Alcoa may be able to generate electricity at a marginal cost of around 3.0 c/kWh, or potentially less if favourable gas price, efficiency and capital and operating cost outcomes are achievable.

b) Electricity Transmission

Electricity transmission costs represent a potentially significant portion of the delivered cost of electricity, particularly toward the extremities of the SWIS.

c) Delivered Electricity Costs

Subject to fuel availability and cost, the preferred location for new power generation facilities to supply a mining or mineral processing development will be on the site of the development. This is illustrated in Table 4 for selected generation locations.

Table 4: Predicted Costs of Electricity at Kemerton

Power Station Location and Type	Delivered Electricity Cost c/kWh
On-site at Kemerton - gas	4.05
Collie - coal	4.55
Eneabba - coal (with -15.8% loss factor)	3.78
(no loss factor)	4.42
Eneabba - gas (with -15.8% loss factor)	3.78
(no loss factor)	4.42
Kwinana - gas	4.36

On-site generation of electricity avoids uncontrollable risks associated with the level of electricity transmission system charges and loss factors. For large loads, on-site generation of electricity is therefore likely to yield the lowest electricity cost for new or expanded electricity-intensive minerals developments. For smaller loads, supply of electricity via the interconnected system will usually be appropriate. Determination of the appropriate supply arrangement will need to be made on a case by case basis.

3.4 Alternative Energy Sources

Environmental considerations, to the extent they are reinforced by the Australian Government's Mandatory Renewable Energy Targets (MRETs) scheme, make the use of renewable energy forms increasingly attractive. However, as illustrated in Figure 8, for the foreseeable future the use of gas and coal offers the most reliable source of competitively priced electricity.

Geothermal energy has a distinct advantage over other renewable energy sources in terms of reliability and cost. The other energy sources suffer in that significant additional expense must be incurred in provision of back-up generation.


Collie Power Station

4 ACHIEVING TARGET ENERGY PRICES

4.1 Comparison of Energy Requirements and Availability

The fuel requirements of the identified minerals sector development opportunities are depicted in Figure 9. In determining the fuel requirements consideration has been given to the costs and efficiencies of electricity generation. Gas based electricity generation has been assumed to be by means of combined cycle plant except in the case of the aluminium smelter, where cogeneration has been assumed. In addition, where a project can use either coal or gas (or electricity derived from either coal or gas) the requisite value for both fuels is depicted. The target (maximum) coal price is represented by the top of the khaki shaded area while the target (maximum) gas price is represented by the top of the blue area.

On the basis of forecast availabilities and prices of coal, gas and electricity it can be seen that the potential exists for many of the identified minerals development opportunities to achieve target energy prices. In the case of an aluminium smelter a number of favourable outcomes will need to be realised, including the achievement of:

- high levels of electricity generation efficiency through the use of cogeneration; and
- a delivered gas price of not more than $2.50/GJ.

The potential exists for these outcomes to be achieved. Simultaneously, development of an aluminium smelter could provide a foundation load to facilitate development of a new source of domestic gas supply for the State.

It is essential to note that, regardless of the level of energy prices that may be achievable, there are numerous other factors that affect the viability of project development opportunities in the south west coast region. Therefore, even if the identified target levels of energy price are achieved there is no certainty that a particular opportunity will proceed.

Figure 7: South West Interconnected Electricity System

Figure 8: Comparison of Predicted Electricity Cost Range

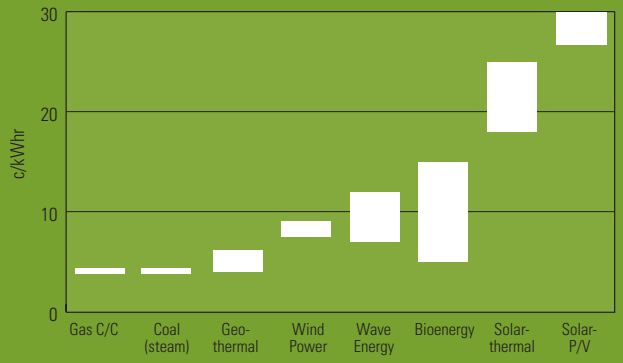
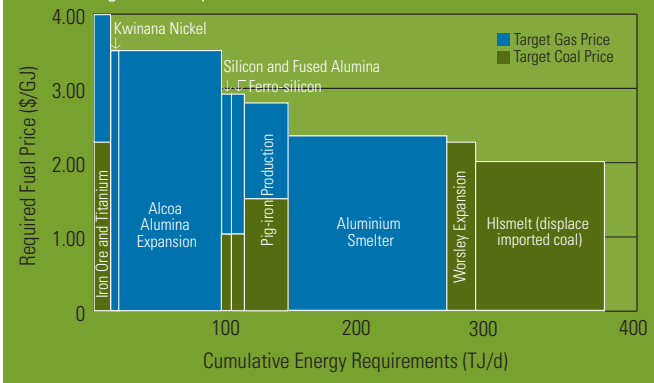


Figure 9: Requisite Fuel Prices and Quantities



Geraldton Port at night

4.2 Economic Modelling

The economic impacts that might be expected to flow from achievement of the identified project developments have been analysed by the Centre of Policy Studies (CoPS) at Monash University using the MMRF-Green, multi-sector dynamic model of Australia's six States and two Territories.

For modelling purposes three scenarios, as described below and summarised in Table 5, were formulated.

Base Case: For reference purposes, a projection of the Australian and State economies, incorporating business-as-usual assumptions for minerals development, was adopted as a Base Case. The Base Case specifically included projects that are already committed or highly likely to proceed at current energy prices.

Development Scenario 1: In addition to the Base Case developments, Scenario 1 included projects of a brownfields nature.

Development Scenario 2: In addition to the Scenario 1 developments, Scenario 2 included projects of a greenfields nature. Scenario 2 also included a general, modest lowering of delivered gas prices, reflecting a flow-through of the benefits of projected pipeline expansion economies.

The economic effects of Scenarios 1 and 2 were assessed by comparison of the values of variables for those scenarios with their value in the base case scenario. The results of this comparison are outlined in Table 5. Realisation of the identified development opportunities will deliver significant economic benefit to the State.

Table 5: Modelling Scenarios and Results *(* totals are subject to rounding errors; totals for Scenario 2 include impact of gas price change)*

Projects Included		Present Value of Increase ($ million 2001 basis, @ 5%)			Long-term, Full-time Employment Increase
		GDP	GSP	Real Cons.	
Scenario 1	Synthetic rutile exp.	339	594	368	100
	HIsmelt - Collie coal use	147	813	520	200
	Silicon smelter exp.	632	1,264	659	500
	Subtotal*	**1,121**	**2,673**	**1,548**	**900**
Scenario 2	Mid West pig-iron	773	2,934	1,951	1,600
	Aluminium smelter	4,563	10,440	5,598	4,900
	Ferro-silicon	128	711	516	600
	Total*	**6,764**	**17,676**	**10,503**	**9,100**

Aerial view of the Stirling Ranges in Stirling Range National Park – South West

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Key Observations

The south west coast region of Western Australia derives significant economic benefit from a diverse mix of mining and mineral processing projects. However, opportunities exist for more rapid expansion or for the development of new mining and processing initiatives. For a number of these opportunities a key determinant of project viability is the availability and cost of energy.

Prospects appear to exist for energy to be sourced at prices that will meet the threshold requirements of these development opportunities, although this cannot be taken to imply that any particular project will proceed. All prospective developments are sensitive to a range of factors other than energy prices including:

- capital costs;
- market factors;
- the availability and cost of other raw materials;
- the availability of, and access to, infrastructure;
- successful development of facilitating technologies, such as the use of coal char to displace imported coal; and
- extraneous factors over which Western Australian project proponents have no influence, such as the provision of incentives for development in other, competing locations, and the considerable time required for State approvals processes.

If all the identified minerals development opportunities go ahead within the south west coast region, significant benefits will accrue to Western Australia. The gross state product could be increased by more than $2 billion per annum, real consumption over the period to 2020 increased by more than $16 billion and 16,200 new jobs created.

5.2 Issues Requiring Attention

In the course of this Study a number of issues have been identified that require attention. The issues are summarised in Table 6. For ease of reference the issues are grouped by subject area.

These identified issues need to be addressed in order that minerals development opportunities, and the significant financial and employment benefits flowing from them, are not lost.

5.3 Recommendations

Table 7 sets out recommendations for dealing with or addressing the issues identified during the course of this Study. Implementation of these recommendations will remove impediments and open up the potential to facilitate further development of the minerals opportunities of the south west coast region, resulting in significant employment and financial benefits for the region, the State and Australia.

Table 6: Identified Issues

Issue	Description
Availability and Price of Energy	
1	Development of the coal reserves of the northern Perth Basin will be required for coal-based pig-iron production in the Geraldton region.
2	Opportunities for rationalisation or expansion of Collie coal production activities should be pursued.
3	Successful development of briquette and coal-char production (using Collie coal) will allow significant benefits to be realised.
4	Capacity constraints in the DBNGP need to be addressed and transportation economies realised need to flow through to delivered gas prices.
5	Perth Basin exploration activities should be promoted, and a range of technical issues addressed.
6	Ongoing development of Carnarvon Basin gas reserves will be important to ensure the continued, competitive availability of gas to meet domestic requirements.
7	It is desirable there be increased competition for electricity supply.
8	Aluminium smelter viability is dependent upon low cost electricity.
9	Geothermal (hot dry rock) technologies show promise and there may be merit in investigating opportunities for application of the technology in the south west coast region.
Environmental Considerations	
10	Policy in relation to greenhouse gas emissions must be clear and non-discriminatory.
11	Government policy in relation to greenhouse and emissions matters must not inappropriately disadvantage Western Australian industry.
12	Initiatives that may reduce possible future costs of compliance with greenhouse constraints or imposts, including potential sequestration opportunities, need to be pursued.
Non-Energy Issues	
13	Ongoing attention must be paid to the level of all costs of operating mining and mineral processing projects within the south west coast region.
14	For iron-ore based developments in the Mid West region to proceed a range of infrastructure constraints must be addressed. Immediate upgrading of rail systems is necessary.
15	Infrastructure issues in the South West and Great Southern regions will need to be addressed.
16	To realise the potential for development of an aluminium smelter in the south west coast region will require a number of energy related and other outcomes to be achieved.
17	The south west coast region must be promoted as the preferred location for development of a titanium metal pilot plant.
18	Considerable time and expense is required to secure State Government project approvals.
19	There may be a future requirement for development of mines in areas that are socially and environmentally sensitive.

Table 7: Recommendations, Including Responsibilities and Timing

Recommendation		Issues Addressed	Responsibility	Due
Recommendations Relating to Availability and Price of Energy				
1	Development of a northern Perth Basin coal mine as a source of energy supply to facilitate iron-ore processing initiatives should be promoted. The Department of Industry and Resources (DoIR) should provide active facilitation and support for industry participants.	1, 13	Industry DoIR	ongoing ongoing
2	Cooperative initiatives (eg, joint venture approach) that may allow improved economies of coal production should be investigated.	2	Industry	2005
3	The Collie coal companies should complete their programmes of research into and commercialisation of coal briquette and coal char production. Gasification related technological developments should be monitored.	2, 3	Industry	ongoing
4	The capacity of the Dampier to Bunbury Natural Gas Pipeline should be expanded and any resulting economy of scale benefits that are realised should flow through to gas transportation tariffs.	4, 8	Industry	ongoing
5	Perth Basin exploration prospects should be further promoted.	5	DoIR	ongoing
6	To assist in promotion of Perth Basin exploration, the Geological Survey Division of DoIR should undertake research that will allow a better understanding of exploration prospects or that will contribute to identification and commercialisation of techniques for production of gas from tight formations.	5	DoIR	ongoing
7	Mechanisms to avoid stranding or flaring of small or associated gas resources should be actively pursued. This could include, for example, the use of CNG technologies.	5	Industry	ongoing
8	An audit of technical regulatory requirements (relating to gas production activities) should be undertaken, with input from industry stakeholders, to ensure Western Australian requirements are not unnecessarily onerous.	5	DoIR with Industry	2005
9	Ongoing development of the gas resources of the Carnarvon Basin, including for supply of gas for domestic purposes, should be promoted.	6	DoIR Industry	ongoing
10	Development of gas reserves to ensure there is competition for supply of gas to meet present and future domestic market requirements should be actively encouraged. This could involve working with industry stakeholders to identify foundation loads that will allow timely development of new gas projects.	6, 8, 13, 16	DoIR and Office of Energy	ongoing
11	DoIR, in conjunction with the Department of Treasury and Finance (DTF), should establish a working group with industry stakeholders to identify and remove barriers to development of an aluminium smelter within the south west coast region.	6, 8, 16	DoIR DTF	2005

Table 7: Recommendations, Including Responsibilities and Timing

Recommendation		Issues Addressed	Responsibility	Due
12	Development of the Western Australian electricity market, to facilitate and promote competition between generators of electricity, should be continued.	7	Office of Energy	ongoing
13	Potential sites in the south west coast region, if any, that are suited for use of hot dry rock electricity generation technologies should be identified by the Geological Survey Division and data made available for consideration by prospective project developers.	9	DoIR	2005
Recommendations Relating to Environmental Considerations				
14	A clear statement of policy regarding carbon dioxide emissions should be developed and promulgated by the Western Australian State Government and applied in a consistent manner.	10,11	DoIR Office of Energy	asap
15	A consistent Australian and international approach to greenhouse gas issues and imposts is required.	11	Office of Energy Australian Greenhouse Office	ongoing
16	Prospective geosequestration sites within the south west coast region should be identified by the Geological Survey Division of DoIR.	12	DoIR	2005
17	The technical and commercial viability of establishing a 'common-user' carbon dioxide sequestration facility to service the needs of industry in the south west coast region should be investigated.	12	DoIR	2005
18	Opportunities for low emissions research (including geosequestration) should be identified and research programmes involving industry or other stakeholders developed to take advantage, if possible, of the Australian Government's low emissions research program.	12	DoIR and Industry	2005, then ongoing
Recommendations Relating to Non-Energy Issues				
19	Opportunities for ongoing productivity improvement need to be identified and pursued to ensure the international competitiveness of industry in the south west coast region is maintained.	13	Industry	ongoing
20	Consideration should be given to assisting industry by identifying issues of general concern and, as appropriate, promoting research through Cooperative Research initiatives (such as the A J Parker Centre for Hydrometallurgy, the WA Energy Research Alliance or the Australian Resources Research Centre).	13	DoIR	ongoing
21	Consideration should be given to carrying out a 'skills inventory' to identify skills requirements and availability in the medium to longer term and to promote training and education programmes to meet identified shortfalls. DoIR should facilitate this process with input from relevant Departments and industry.	13	DoIR	2005

Table 7: Recommendations, Including Responsibilities and Timing

Recommendation		Issues Addressed	Responsibility	Due
22	A solution for the Mid West infrastructure constraints needs to be identified and implemented immediately in order to ensure proposed iron ore developments in the region are not further impeded. In order to achieve this, a working group including DoIR, the Department for Planning and Infrastructure (DPI), industry and the major infrastructure providers needs to be established to facilitate necessary solutions.	13, 14	DPI, DoIR	2005
23	DoIR and DPI, in conjunction with the Mid West Development Commission should undertake a focussed review of medium and long-term infrastructure requirements to develop plans and strategies to ensure infrastructure is developed in line with industry requirements. The review should address transportation and port infrastructure as well as water, electricity, the availability of industrial land, and social infrastructure requirements and should include input from industry stakeholders.	13, 14	DPI, DoIR and Mid West Development Commission	2005-2006
24	Consideration should be given, if necessary, to the use of innovative infrastructure financing arrangements.	14	DoIR and State Treasury	as required
25	DoIR, with the Department of Planning and Infrastructure and with input from key stakeholders in the minerals and other industries, should carry out a comprehensive study to identify long term infrastructure requirements in the Southwest and Great Southern regions. Coordinated strategies should be developed to ensure infrastructure is in place as required to support regional development.	15	DoIR	2005
26	DoIR in conjunction with the Great Southern Development Commission should carry out a study to determine the region's competitive position in regard to industrial and commercial development and determine how this potential should be promoted.	15	DoIR, Great Southern Development Commission	2005
27	The benefits that may be realised through development of an aluminium smelter are significant and, accordingly, appropriate project facilitation should be provided.	16	DoIR State Treasury	as required
28	DoIR should promote the development of a pilot plant to demonstrate new titanium metal production technologies. DoIR should be aware of companies involved in this avenue of pursuit in order to successfully promote the south west coast region.	17	DoIR	near term
29	A more rigorous, fully resourced and empowered approach is required to implement the recommendations of the Keating report to ensure Government approvals processes are not an obstacle to project developments or expansions. The State Government must clearly understand industries' concerns in regard to the approvals processes and implement an integrated approvals system consistent with "world best practice".	18	DoIR, CME	2005
30	DoIR should coordinate matters relating to development of mines in sensitive areas. This will involve working with industry and communities to identify and address issues at an early stage so that there can be a logical and timely progression of mine development.	19	DoIR	ongoing

Interpretation and Glossary

All dollar amounts in this document are expressed in Australian dollars. Conversions between US and Australian dollars have been carried out at an exchange rate of 0.7 US$/A$ and calculation results have been rounded.

Abbreviations used in this document are defined within the text. However, a number of standard industry terms and units are also used, including the following:

c/kWh – cents per kilowatt hour.

DRI – direct reduced iron.

E – exa (or 10^{18}). Hence, EJ means exajoule.

Fe – chemical abbreviation for iron. Hence %Fe means percentage of iron.

gas – Unless the context requires otherwise the term 'gas' is a reference to natural gas including coal seam methane.

G – giga (or 10^{9}). Hence GJ means gigajoule.

GDP – gross domestic product.

GSP – gross state product.

J – joule (a measure of energy and heat).

k – kilo (or thousand). Hence, kt means kilotonne.

kWh – kilowatt-hour (a measure of electrical energy). 1 kWh is equivalent to 3.6 MJ.

LNG – liquefied natural gas, being natural gas that has been cooled so that it turns into a liquid.

M – mega (or million). Hence, Mt means megatonne and MWh means megawatt-hour.

P – peta (or 10^{15}). Hence PJ means petajoule.

t – tonne.

T – tera (or 10^{12}). Hence TJ means terajoule and TJ/d means terajoules per day.

TCF – trillion cubic feet, an imperial measure of gas quantity. 1 TCF of gas is comparable to 1 EJ of gas.

tpa – tonnes per annum.

W – watt (a measure of electrical power).

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