THE THREAT TO AND DANGERS OF COAL

THE COAL INDUSTRY:

By any standards, the coal industry is huge. It is a very important part of the economy and a significant source of government revenue in the form of GST paid to the Commonwealth and Royalties paid to the States. Australian coal exports are worth more than double the value of the next largest export commodity (iron ore) and in 2009 are expected to be valued at over $26 billion.

Over 120 coal mines are in operation in Australia and the number is expanding with most growth occurring in Queensland and New South Wales. Almost $200m. per annum is being expended on exploration and evaluation of coal deposits which may be suitable for mining.

The result of this activity is that coal mining continues to grow, bringing increased prosperity to regional Australia. This comes in the form of growth of new and existing towns and provision of health, education and other social services. In addition, the industry contributes to skills training, scholarships and supports community projects such as sporting facilities.

The coal industry has developed technology, equipment and procedures which make it one of the safest in the world. It has developed into an efficient and reliable supplier of coal which, because of its very low sulphur emissions, makes it the worlds largest coal exporter.

The industry directly employs over 30,000 people and as many again in coal related industries such as transport, engineering services and the development and operation of infrastructure. Importantly, most of those jobs are located in Regional Australia.

At present, 88% of our electricity needs are generated by burning coal, the rest being provided from gas fired power stations or hydro and wind. Moreover, demand for electricity is growing at a rate of over 3% per annum placing increasing demand on the need to build new power stations. At least in the very short term, these are likely to be fired by burning fossil fuels, coal in the eastern States and gas in Western Australia.

The domestic market for coal uses about 75 million tonnes of coal per annum. 65 million tonnes of this is used to generate electricity with the balance being used for smelting and the production of metals, particularly steel, copper and alumina. In addition, coal tar is used for the production of many chemicals used in manufacturing industries.

At present, our demand for electricity is steadily growing and that growth is being met by coal fired power stations. They are able to generate base load electricity efficiently, thanks to well developed technology and infrastructure. More importantly, electricity generated from coal is cheaper than that produced from any other source.

On average, Australian electricity costs consumers only 60% of the price charged in European Union countries. This gives Australia a valuable competitive trading advantage in both its domestic and the international markets it supplies with manufactured goods. Ability to produce such cheap electricity has been aided by Government subsidies which are paid to encourage both the production and use of coal.

No less significantly, the coal industry is a major source of Government revenue. This takes the form of GST paid to the Commonwealth and Mining Royalties paid to State

Governments, particularly important to Queensland and New South Wales. Foreign exchange earnings from the export of coal make an important contribution to national reserves. And then there is the question of the billions invested in power stations.

The coal industry is therefore rightly seen as having a very important position in the Australian economy.

However, there is a major problem which both the coal industry and government are attempting to deal with. That problem is that fossil fuels in general and coal in particular are the major source of greenhouse gas emissions. In 2006 Australia emitted about 576m. tonnes of greenhouse gas more commonly referred to as carbon dioxide equivalent or, for short, CO_2-e.

Over 70% of our greenhouse gas emissions arose from the burning of fossil fuels such as coal, oil and gas with the balance arising from land use, farming and forestry. Use of fossil fuels resulted in over 400m. tonnes of CO_2-e emissions. 280m. tonnes of these emissions arose from burning coal to produce electricity.

Australia has the highest per capita greenhouse gas emissions in the world and those emissions are held responsible for global warming and all of the very real and very dangerous changes likely to result from that warming. They include climate change resulting in reduced rainfall and availability of water for our most important areas of food production, particularly major commodities such as grains, meat and wool.

Other effects arising from global warming are likely to be increasing deaths arising from heat stress and the spread of diseases, damage to low lying coastal areas, severe damage if not destruction of the Great Barrier Reef and reduced snowfall over our winter resorts. All have significant environmental effects and threaten costly socio-economic outcomes.

The major culprit of CO_2-e emissions in Australia is coal, or rather the way we use it.

A problem facing Government and the Opposition is the development of policy on fossil fuels, particularly their use for generating electricity. Both know that it is only a matter of time before coal declines as the major source of domestic electricity production because it is the major source of CO_2 pollution and is a finite commodity.

Both are also aware of the importance of coal to the national economy and the fact that unilateral action by Australia alone can do little to mitigate global warming, or its effects. After all, Australian CO_2-e emissions amount to only 1.4% of world emissions. However, they also know that Australia can set a good example to larger emitters by reducing its own emissions and assisting others to do likewise.

No Commonwealth or State Government is willingly going to place the Australian coal industry at risk, no matter how well disposed they are to reduction of CO_2-e emissions. For all of the reasons noted above, first the Howard then the Rudd Governments have allocated funds ($500m) to assist develop technology to capture and sequester CO_2-e emissions from power stations, better known as ‘clean coal’ or CCS technology.

The idea is to use chemical scrubbers to remove CO_2 at the point of emission through absorption by various amino based solvents. Captured CO_2 would then be compressed into a liquid and piped to a point where it could be safely buried in leak proof cavities deep beneath the surface.

It is expected that, once proven, this technology will be retro-fitted to all existing fossil fuelled power stations in Australia and overseas. If the technology is successfully developed, it would enable major CO_2-e emitters such as China, USA and India to use it and significantly reduce their emissions. It would have global benefits and would enable Australia to continue mining and exporting coal and using it to generate its own electricity.

The problem with CCS is that it has yet to be shown as a cost-effective commercially viable option which justifies both the capital expenditure and recurrent operating costs. The latter include the cost of amino based chemical scrubbers to capture CO_2 emissions, stripping the CO_2 out, compressing it into liquid form and transporting it to a location where it can be injected into a safe, secure storage area.

All of these measures require energy, a lot of energy, variously estimated at between 10% - 30% of power station output. This is expensive. The current state of CCS technology demonstrated by CSIRO, has shown a capacity to capture no more than 3-5% of CO_2 emissions. Further, the future of CCS technology is far from certain. Despite these vicissitudes and uncertainties the Australian Government has committed $500 million towards its development.

It is unlikely that existing or new power stations will have CCS technology, which will capture 90% of CO_2-e emissions, much before 2020. The technology will have to be retro-fitted at considerable expense and operated at even greater expense. Nor is it certain that all power stations will have close proximity to subterranean storage secure enough to ensure that there will never be CO_2 leaks. The cost of transporting and storing captured emissions may therefore be higher than anticipated.

These additional costs would push up the price of domestic electricity generated from fossil fuels. On an even playing field this would increase the competitiveness of electricity generated from renewables, posing a threat to the commercial viability of coal fired power stations. Importantly, there is no guarantee that CCS technology will be taken-up by major emitters like India and China if the additional cost of using it makes their economies uncompetitive. As noted above, CCS is an uncertain and expensive technology.

The second measure taken by the Commonwealth Government to protect the coal industry is to provide it and those who use coal to meet their energy needs with subsidies. Government has also announced its intention of providing major coal users, such as power stations and smelters, with some free emission licences to ease the cost burden of having to buy licenses on the open market.

That burden could significantly eat into the profits of larger polluters such as power stations and devalue capital assets. Such devaluation could prompt lenders to recall loans made to power station owning companies or make it difficult for them to borrow. However, as described in Part 3 of this paper, The Threat from Above, existing power stations need not be dependent on burning fossil fuels in order to generate electricity.

Free emission licences are more than a subsidy. They are also a means of keeping the price of electricity generated from fossil fuels below that generated by other means, particularly from renewable sources. They distort the market and ensure that it is more difficult for electricity produced from renewable sources to compete with coal or other fossil fuels.

In the short term, this may sustain the domestic coal market and cheap electricity which benefits industrial consumers. However it does nothing to send a price signal to consumers encouraging them to reduce consumption as a means of reducing dangerously high levels of CO_2-e emissions. And that presents Government with another problem, that of achieving a responsible target for reducing those emissions.

What if CCS technology proves too expensive? What if it can not be developed in a timely manner to sharply reduce CO_2-e emissions arising from burning coal to generate electricity? What if cheaper and cleaner alternatives to coal are developed? These possibilities are very real and could well threaten the future of first the domestic market and later, the export market for Australian coal.

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THE THREAT FROM BELOW:

GEOTHERMAL energy takes the form of heat produced by the decay of radioactive substances such as thorium and potassium. These are found in granites which permeate and heat it up to 300ºC. in non-volcanic areas such as those found in Australia and central Europe.

Unlike other countries, Australia has vast deposits of this granite at temperatures of 270-300ºC just 3-5 km below the earths' surface. It also has the technology to locate and delineate hot rock deposits and drill holes into it. When water is pumped over the hot granite, it causes the rock to fracture creating an underground heat exchanger and superheated steam under very high pressure.

This superheated steam can be accessed by drilling 'production' wells. The pressure pushes it up to the surface where it is piped through a heat exchanger. This heats another fluid, possibly one with a boiling point below 100ºC., which turns to steam and is used to drive a turbine which turns a generator, producing electricity.

There are therefore two separate enclosed systems, both circulating through a heat exchanger, neither exposed to the atmosphere or requiring additional water. Superheated steam from underground leaves the heat exchanger in a cooler, fluid state and is pumped back underground to be re-heated by the hot granite. Steam flowing from the turbines is returned to the heat-exchanger to be reheated and once more pass through the turbine.

It is thought that after several decades, the subterranean granites being used to produce superheated steam may gradually cool. However this is not known to occur and may not do so since radioactive isotopes in the granite will continue to decay and produce heat. Heat from deeper granites may also help maintain temperature through convection.

Geothermal electricity is already being generated in this way in Germany and America, so the technology needed to tap into and use subterranean heat is well understood. However, the granite deposits in Australia are much hotter than those found elsewhere. Although ability to tap their heat to generate electricity has yet to be demonstrated, there is no reason why it will not be achieved in a successful, affordable manner.

Importantly, it is estimated that there are sufficient hot granite deposits to generate all of our needs for base load electricity for several hundred years. Even more importantly, the process is emission-free. No CO_2 emissions or other pollution which could contribute to global warming and therefore no need to purchase an emissions license. No need to pay a carbon tax or use expensive technology for carbon capture and sequestration (CCS) as coal and other fossil fuels must do.

Given a choice between electricity generated from polluting fossil fuels and energy produced from pollution free geothermal steam, what would you choose? Most Australians, industry included, would go for geothermal, particularly if it cost less, even if it cost slightly more than electricity generated by burning fossil fuels. We would gain the satisfaction of knowing that by using clean energy we were doing the right thing by minimising our contribution to global warming.

Industry does not care where its electricity comes from, as long as it is reliable, continuously available and relatively cheap. Australian electricity is among the cheapest in the world, thanks to government subsidies paid to producers and users of coal. This gives us a competitive edge which sustains our ability to manufacture rather than import products for the domestic market. It also gives our exporters the ability to compete for export markets with countries which pay lower wages than we do.

The question to be asked is: Will geothermal electricity be cheaper than electricity produced from fossil fuels? At present we can not be certain since large-scale production of geothermal electricity has yet to be undertaken in Australia.

However, the cost of drilling wells, building power stations and transmitting electricity over long distances are known to the companies engaged in these activities. Knowing these costs enables calculation of the cost of generating electricity by this means and this is variously estimated at between $72-$90/MWh by 2020.

Variation in estimated cost of using geothermal steam to generate electricity arise from differences in temperature of the granites accessed for this purpose. The higher the rock temperature, the higher the pressure and temperature of steam produced, increasing both the efficiency and size of turbines it can turn.

The cost of generating electricity by burning fossil fuels to produce the steam required to drive a turbine is estimated to be between $76/MWh for coal and up to $90/MWh for gas by 2020. Generating costs from use of steam produced by geothermal rock or burning fossil fuels appear to be similar, with geothermal having the edge.

However, burning fossil fuels emits CO_2. It is therefore necessary to add the cost of an emissions license or the cost of using CCS technology to the cost of generating electricity. Neither of these costs are known yet but what is known is that they will push up the cost of using fossil fuels.

From this it can be concluded that the cost of electricity generated from geothermal steam is likely to be competitive with power generated from fossil fuels. However, electricity generated from fossil fuels must bear the cost of emissions licenses or CCS technology, making it much more expensive than geothermal power.

In order to protect the domestic market for coal, government could subsidise coal fired power stations to cover the cost of CCS technology and any CO_2-e emissions which it does not capture. Perhaps coal producers would reduce the price of their coal to cover those costs rather than go out of business?

Alternatively, Government could impose a ‘heat tax’ on companies generating electricity from geothermal steam, but this would do no more than push up the price of electricity to the detriment of industry and households.

The question is, would these kinds of market distorting protection be offered in the face of a growing ability to meet national demand for pollution free and relatively cheap electricity generated from geothermal steam? Or would government prefer to exercise the role of managing the transition from fossil fuel to renewable in an orderly way with the primary aim of maintaining the competitive position of Australian industry?

Geodynamics Ltd holds rights to some of the hottest and most extensive granite deposits in Australia and is the leading pioneer in mining and using geothermal heat. It has stated authoritatively that once it has completed a 50MW demonstration power station run on geothermal steam, by 2012, it will be in a position to construct hundreds of others.

It can be expected that these power stations and those built and operated by other companies engaged in mining heat, will be able to meet national growth in demand for electricity. To an increasing extent, geothermal steam will displace coal as the source of base load electricity after 2020. By 2030, competition from geothermal energy may well have reduced the domestic coal market by 50% and fully replaced it by 2050.

On the basis of information currently available geothermal electricity will be cheaper than that produced from fossil fuels. In an open market, on a level playing field, it will undersell coal generated energy and therefore be in greater demand from industry and households alike. The only limiting factor will be the speed with which the geothermal industry can drill into hot granite deposits, construct power stations and feed electricity into the national grid.

Industry and households are aware of the dangers posed by global warming and would prefer to use emission free electricity. They would much prefer to use it if it was cheaper than that produced from burning fossil fuels such as coal, oil or gas.

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THE THREAT FROM ABOVE:

SUNLIGHT is the total spectrum of the electromagnetic radiation given off by the Sun. This radiation can be used to produce electricity in two basic ways, directly by exposing photovoltaic cells to sunlight and indirectly by using solar heat to produce steam for generating thermal electricity.

Photovoltaic cells (PVC's) are assembled into modules or panels which can be linked to form an array. They have many applications, particularly in remote locations where power from the grid can not be provided. Accordingly they are most commonly used to provide electricity to space stations and probes, distant housing, marine beacons, water pumps, radio-telephone and other remote facilities.

The drawback with photovoltaic cells is that they are inefficient, converting less than 15% of available sunlight into electricity. Moreover, the cost of manufacture and the need for batteries to store electricity for use after sunset, make the electricity they produce very expensive – over twice the cost of electricity produced from fossil fuels.

PVC's are unlikely to replace fossil fuels even though they have the potential to reduce CO_2 emissions by replacing conventionally generated electricity. They are used extensively in Germany and other countries where generous subsidies and purchase of surplus electricity are offered to households purchasing and installing them. Similar subsidies and purchase of electricity produced by them are offered in Australia.

Until the efficiency of PVC's and manufacturing costs have been significantly improved, their use as a means of reducing CO_2-e emissions is highly debatable. There are more cost-efficient ways of using sunlight to generate electricity. For this reason government support for the use of PVC's should be limited, primarily for the production of electricity in remote areas.

If governments wanted to effectively reduce CO_2-e emissions, they would more actively advocate and support installation and use of solar hot water (SHW) panels rather than PVC's. With improved insulation of hot water storage tanks, SHW panels can reduce domestic electricity consumption by 25%-30%. Installation of a million SHW panels would make a significant reduction in demand for electricity and do so in a far more cost effective manner than domestic PVC installation.

A far older technology involves concentrating or focussing sunlight on a substance with a view to causing it to heat. This involves the use of an array of mirrors, or polished bronze shields in the case of Archimedes who used it to destroy Roman warships attacking the Greeks of Sicily in 213BC. Such an array, better known as a heliostat, is used to focus sunlight on to PVC's or a substance which either directly or indirectly creates steam to drive a turbine.

It has been proposed that sunlight be reflected by an array of mirrors, a heliostat, on to a massive array of PVC cells to generate electricity more efficiently and do so on a large scale. This technology is to be used for a solar power station to be built near Mildura at an estimated total cost of $420m., including $130m. in the form of grants from the State and Commonwealth Government.

The proposed Mildura power station, the largest of its kind in the world, will have the potential to meet the needs of 45,000 homes and reduce greenhouse gas emissions from fossil fuelled power stations by 400,000 tonnes a year. The cost per MW of electricity generated has not been disclosed but is expected to be well above the cost of generating electricity from burning fossil fuels. However, it is pollution free.

Arguably, solar power stations using PVC's should only receive government support if the cost of electricity produced is about the same or less than that produced from fossil fuels. If it costs appreciably more, why would (or should) public monies be subscribed to help pay for capital or recurrent costs. Government should only be expected to assist in the development of technologies which reduce CO_2-e emissions in the most cost-efficient and effective manner.

A number of institutions are actively engaged in research aimed at achieving significant improvement in the efficiency with which PVC's are able to convert sunlight into electricity. A breakthrough will probably be achieved within the next 5-10 years and when this occurs it will make widespread domestic use of PVC's a more economically viable proposition and vastly enhance the output of solar power stations based on use of a heliostat to concentrate sunlight onto a large array of PVC's.

The most promising heliostats are those where the mirrors are kept focussed on the heating chamber, irrespective of the ever changing position of the earth in relation to the sun. The larger the heliostat, the higher the temperature which can be achieved in the heating area.

Sunlight concentrated in the heating chamber can be up to 1,000 times the strength of normal sunlight. The heating area is usually elevated, often located at the top of a tower which may have a moveable head which can accurately track the sun.

The substance heated is any that can retain and produce sufficient heat to produce steam able to drive a turbine – hence the descriptor, 'solar-thermal'. Ability to retain heat is important since a heliostat can only concentrate sunlight when the sun is at least 5^{o} above the horizon and is clearly visible. Hence the ideal location for a heliostat is a desert area where there is little cloud and maximum exposure to sunlight.

Demand for electricity does not stop when the sun sets. Indeed, the contrary may be true. We need base load electricity, power which is constant, reliable and available 24 hours a day, every day. Solar thermal energy can not provide this - yet. However, by heating materials which retain heat, steam can be generated from it long after the sun has set.

One such substance is a mixture of sodium chloride (common salt) and potassium chloride. Solar heat focussed on to a mass of this salt is sufficient to make it molten. Molten salt is able to retain sufficient heat to produce steam to drive a turbine and generate electricity up to 7or 8 hours after sunset.

By using salt and other heat retaining substances, which are stored in a molten state under pressure in tanks, it is possible to generate electricity from solar-thermal sources for up to 18 hours/day. Accordingly, solar-thermal already has the capacity to replace up to 75% of the coal currently used to generate base load electricity.

It is not unreasonable to assume that improvements in the design and manufacture of heliostats and the heat retention capacity of heated material will occur. This will result in the cost of electricity generated from solar-thermal sources falling significantly until it is much closer to that of electricity generated from burning fossil fuels.

The first solar-thermal power station to be built in Australia will be at the remote town of Cloncurry in north-west Queensland, population 2,500. The power station will cost $31 million of which $7 million is a grant made by the Queensland Government.

The power station will be completed in 2010 and comprise a heliostat of 8,000 mirrors (60,000 sq. m). The heliostat concentrates sunlight on to 18 short towers each of which is topped by a heating area containing a solid block of graphite. Water pipes run through each block. The heated graphite retains sufficient heat to rapidly convert the water into steam which is used to drive a turbine and generate electricity.

The power station will have a capacity of about 10 MW and generate 30 million KWh/annum, sufficient to meet all of Cloncurry's needs. Cost of production is estimated to be $1.03/KWh., which is marginally above the cost of generating electricity at that location from diesel oil but which will reduce CO_2-e emissions to zero and remove the need to haul fuel 700 km. from the nearest port – Townsville.

Solar-thermal power stations are a novelty in Australia but are becoming widely used in other parts of the world, particularly in Spain and the United States, countries which have pioneered their development. In Spain, 5 power stations with a capacity to produce 225 MW have been built or are under construction.

In the USA, 18 solar-thermal power stations are either in use or under construction and have a capacity to produce some 2,500 MW. Applications are being considered for development of additional power stations with a capacity to generate a massive 70 GW of electricity. Other countries using or building solar-thermal power stations include Algeria, Egypt, France, Iran, Israel, Morocco, South Africa and several others.

Solar-thermal power stations are particularly well suited to the more remote desert and semi desert areas of Australia where sunlight is abundant and largely unobscured by cloud. Proposals to build power stations in such areas, with very large heliostats covering an area of 10 square kilometres or more have been made by several Australian and American companies and are receiving serious consideration by government.

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CONCLUSION:

So, where do these threats leave coal? Dependent on Government support in the short term, in a decidedly precarious position in the medium term and, in the longer term, neither needed or used.

In the short term (1-5 years), the coal industry will be relatively unconcerned by the development of renewable energy sources. It is reasonable to expect that solar and geothermal energy will be able to do no more than fill growth in demand for more electricity. Should they not be able to do so in the short term, additional fossil fuelled power stations will be built. This may result in slight growth in demand for coal by the domestic market, unless electricity consumption is reduced through more efficient use.

With introduction of a carbon trading scheme the cost of generating base load electricity from fossil fuels will become more expensive. Power stations will have to purchase licenses to cover most, if not all, of their CO_2-e emissions. To off-set this increase, Government has indicated to power generators (our most prolific polluters) that it will provide them with up to a third of the emissions licenses they will need, free of charge.

Even so, this will still result in generating costs and electricity tariffs rising. The effect of those rises can be expected to result in consumers using less electricity than they otherwise might. To the extent that this occurs, power stations will reduce output and in doing so, use less coal, reducing their CO_2-e emissions and the need to purchase emissions licenses. Power stations may use 10% less coal than they do at present.

Other coal users, such as smelters, will have to judge whether it is cheaper for them to continue their present level of coal use and purchase carbon emission licences, or take steps to reduce their carbon emissions and avoid the need to purchase licences. Some tell us that they will contemplate writing off a large portion of their capital investment in Australia and moving to another country where polluting is free. They will take the cheapest option and pass on the cost to their customers.

It might be expected that in the initial year of carbon trading (2010/11) the price of carbon may be about $20-$25/tonne. However, this price should be expected to increase each year as carbon reduction targets also increase. Putting an initial value on carbon and increasing it thereafter will result in a gradual rise in the cost of electricity generated from fossil fuels.

This will stimulate research and development into alternative sources of energy, resulting in improved technology for its use and storage. In the medium term (5-25 years) this will result in ability to generate electricity from renewable sources at competitive costs equivalent to or below the cost of fossil fuels. As this occurs, demand for electricity can be expected to grow, particularly from a growing number of electric vehicles.

Market demand for the cheapest source of electricity and competition between the major renewable sources (geothermal and solar) will continue to push the price of base load electricity down, well below that of power generated by fossil fuels. As this occurs, role out of geothermal power stations will gain momentum. The first solar power stations using very large heliostats and capacity to generate 500MW or more can be expected to come on line by 2015-18.

It should be expected that as this occurs, CCS technology may have developed to the point it is able to capture at least 90% of CO_2-e emissions at source. However the capital cost of retrofitting CCS to existing fossil fuelled power stations, particularly the worst emitters, and its operating costs will sustain the higher cost of generating electricity from fossil fuels. Power station owners will have to consider whether to invest in CCS or a more cost-effective method of generating electricity.

Within 10-15 years, options available to owners of existing power stations may include:

- Replacing part or all of the fossil fuel used to generate electricity with solar energy
- Selling-off their generators to geo or solar-thermal operators, or
- Continuing to operate with reliance on uncertain government subsidies.

It is reasonable to expect that by 2020 base load electricity will be increasingly generated from renewable sources and that a real decline in the domestic market for coal will by then be evident. That decline will continue to grow as cheaper geo and solar-thermal electricity more rapidly displaces coal. By 2030 it is predicted that the domestic market for coal will have declined to less than 50% of its present size and that thereafter it will rapidly shrink to zero.

The task of government is and will increasingly be to plan for and manage the smooth and inevitable transition from fossil fuels to renewable sources if electricity. This must be done in a way which is not disruptive of the economy as a whole. It must include re-training and re-employment of the workforce currently engaged in the production and use of coal.

Australia has an internationally unmatched competitive advantage in having access to vast deposits of the hottest geothermal rocks found anywhere in the world. These enable it to supply its economy with relatively cheap, pollution-free base load electricity. This will stimulate economic growth by attracting industries in need of reliable lower priced electricity and encouraging existing industry to expand.

Export of coal may grow in the short to medium term but its continuation is dependent on two considerations:
First, the availability of proven, effective and affordable CCS technology and:
Second, inability of renewable sources, particularly solar, to compete with fossil fuels.

As already discussed, development of affordable, effective CCS technology is not only problematic, its eventual achievement is very far from certain. Key problems to be overcome are those of efficiently removing CO_2 at the point of emission, transporting it to secure storage and the cost involved being low enough to keep generating electricity from coal below the cost of generating it from sunlight or other renewable sources.

Without CCS, on-going use of coal as the prime source of electricity required by countries importing it from Australian can only continue if they ignore its polluting effect. As the atmospheric content of CO_2 increases and the adverse impact of global warming and ocean acidification become more evident, UN trade sanctions (yet to be approved) will make that an untenable option.

Recent advances in the application of heliostat technology to generate electricity have been rapid. They are now at the point where the capital cost of building a sola power station are comparable with the cost of building a fossil fuelled power station. However, the cost of generating solar electricity is well above that of generating it from coal. This position will continue unless there are further advances in solar technology.

It would be most unwise and unrealistic to believe that in the medium term (5-25 years) there will be no such advances. Placing a value on carbon will by itself stimulate research and development into renewable sources of electricity as well as innovation into its better storage and wider use, as will competition within the renewable energy sector.

Government has already set aside substantial funds to help cover the cost of these activities. It did not do so in the belief that they would be unproductive. On the contrary, availability of these funds should be seen for what they are, an investment providing diversity and options in the event that its preferred option, CCS technology, fails to come up with the goods.

Sunlight is of course globally available and, unlike coal, is free, while the reward for advances in heliostat and PVC technology are glittering for innovators and users alike. As soon as technology enables solar electricity generation at a cost equivalent to or less than coal or other fossil fuels, coal importing countries will stop using coal. This will bring about a quite rapid decline in Australian coal production and exports.

When will this occur? Certainly in the medium term. Probably within the next 15 years. Even if CCS technology permits use of coal without greenhouse gas emissions, the additional expense will make it difficult to compete with renewable sources of electricity. Coal importing countries would prefer self sufficiency rather than dependence on overseas suppliers and will, at the first opportunity, switch to solar- thermal electricity.

What of the future for coal exports? Pretty good until about 2020, then gradual decline until about 2030 when it is predicted that the export market for coal will have declined to less than 50% of its present size. Thereafter, as with domestic demand, overseas demand for coal will rapidly shrink to zero.

By 2050, little if any coal will be used in Australia or by those countries which presently import it from us. The Australian coal industry will probably reach its peak by 2010. Government will then have the task of planning for its orderly decline, re-training and re-employment of its workforce and ensuring a smooth transition to generating electricity from renewable sources.