COOPERATIVE RESEARCH CENTRE FOR COAL IN SUSTAINABLE DEVELOPMENT

Established and supported under the Australian Government's Cooperative Research Centres Program

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE THIRD ASSESSMENT REPORT – A REVIEW

TECHNOLOGY ASSESSMENT REPORT 21

Authors:

L. Leung
P. Scaife

BHP Billiton - NTC

December 2002

QCAT Technology Transfer Centre, Technology Court
Pullenvale Qld 4069 AUSTRALIA
Telephone (07) 3871 4400 Facsimile (07) 3871 4444
Email: Administration@ccsd.biz

Disclaimer

Copyright

DISTRIBUTION LIST

CCSD

Chairman; Chief Executive Officer; Research Manager, Manager Technology; Files

Industry Participants

Australian Coal Research Limited ....Mr Ross McKinnon
BHP Billiton Minerals - Coal ....Mr Ross Willlims
CNA Resources...Mr Rod Hall
CS Energy ....Dr Chris Spero
Delta Electricity ....Mr Steve Saladine
Queensland Natural Resources and Mines..Ms Mary Worthy
Rio Tinto (TRPL)..Mr David Cain
Tarong Energy...Mr Burt Beasley
The Griffin Coal Mining Co Pty Ltd ....Mr Jim Coleman
Wesfarmers Premier Coal Ltd..Mr Peter Ashton
Western Power ....Mr Keith Kirby
Xstrata Coal Australia Pty Ltd ....Mr Barry Isherwood

Research Participants

CSIRO ……..Dr Adrian Williams
Curtin University of Technology ....Dr Barney Glover
Macquarie University ....Prof Peter Bergquist
The University of Newcastle ....Prof Adrian Page
The University of New South Wales ....Prof David Young
The University of Queensland ....Prof Don McKee

Retiring Participants

ARCO Resources Ltd..Mr William Ash
BHP Coal Pty Ltd ....Mr Alan Davies
Pacific Power ....Dr Allen Lowe
Rio Tinto Pacific Coal..Mr Duncan Waters
Stanwell Power ....Mr Des Covey

Cooperative Research Centre for
Coal in Sustainable Development
QCAT Technology Transfer Centre
Technology Court
Pullenvale, Qld 4069
Telephone: (07) 3871 4400
Fax: (07) 3871 4444

Feedback Form

To help us improve our service to you may I ask you for five minutes of your time to complete this questionnaire. Please fax or mail it back to me, or, if you would prefer, give me a call.

ATTENTION **MANAGER TECHNOLOGY**

FAX NO **07 3871 4444** **DATE** ....

FROM **NAME:** ....
COMPANY: ....

REPORT TITLE: **INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE - A REVIEW**
AUTHORS: **L. Leung and P. Scaife**

Would you please rate our performance in the following areas by ticking the appropriate box:

The Research	Agree	Neutral	Disagree	Don't Know
This work has achieved its research objectives				
This work has delivered to agreed milestones				
This work is relevant to my organisation				
Communication of progress has been timely & useful				

The Report

The report is well presented				
The context of the report is clear				
The content of the report is substantial				
The report is clearly written and understandable				
This product is good value				

Any further comments which would assist us in better serving your future requirements?:
……………………………………………………………………………………………………
……………………………………………………………………………………………………

Are there any people you would like to add to our distribution list?:

……………………………………………………………………………………………………
……………………………………………………………………………………………………

Thank you for your response

Intergovernmental Panel on Climate Change – Third Assessment Report

Lawrence Leung* and Peter Scaife*

*** BHP Billiton Minerals Technology, Newcastle, NSW 2287, Australia

A key issue for the CCSD is international concern with, and response to, the increasing levels of greenhouse gases in the atmosphere. This is a fundamental driver for many CCSD projects. The Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC), published in 2001, provides an important overview of the Science, Impacts, Adaptation and Mitigation options.

Dr Lawrence Leung has prepared a summary of each of the three assessment reports:

- Science (WG1)
- Impacts, Adaptation, and Vulnerability (WG2)
- Mitigation (WG3)

These summaries, in pdf format, are attached.

An Executive Overview is provided below, to assist in the digestion of the wealth of information contained in the summaries. Implications for the coal industry are also included.

KEY WORDS: greenhouse gas; climate change; science; impact; adaptation; vulnerability; mitigation; energy; coal

1. Science

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities"

The earth's climate has changed on both global and regional scales, since the pre-industrial era, with some changes being attributable to human activities.

The global average surface temperature has risen 0.6°C since 1861, with most of the observed warming during the past 50 years likely to be due to increases in GHG emissions resulting from human activities.

Modelling shows that the projected CO_2 concentration in 2100 ranges from 540 to 970 ppm (*cf* 368 ppm in 2000), resulting in an increase in global average surface temperature of 1.4 to 5.8°C.

In the 21st Century, greenhouse gas forcing could set in motion large scale, high impact, abrupt changes in physical and biological systems.

2. Impacts, Adaptation and Vulnerability

TAR examined 4 basic scenarios in considering impacts and vulnerability:

- concentration stabilisation,
- emission stabilisation,
- safe emission corridor, and
- other mitigation scenarios

These scenarios, relating to population, land use, etc, are used together with climate change scenarios. The scenarios include energy- related CO_2 emissions; several also include CO_2 emissions from land- use changes and industrial processes, and other important GHGs.

Technological improvement is a critical element in all mitigation scenarios. Some models focus on policy of supply- side technology introduction, while others emphasise efficient demand- side technology.

Most scenarios introduce carbon taxes or constraints on emissions or concentration levels; emission permit trading is also introduced in more recent work.

Impacts

Climate change will have both beneficial as well as adverse effects (predominate at higher temperature increases) on environmental and socio-economic systems.

- greatest adverse impact on developing countries (less adaptive)
- adaptation can lessen the impacts

To minimise impacts, there is a need to reduce pressure on resources, improve management of environmental risk, and enhance adaptive capacity.

While climate change is expected to result in more floods, and create more uncertainty for water resources, other issues (such as population growth, and development) may have a greater impact than climate change.

The predicted impacts are:

- For agriculture and food supply, the yields in the tropics will decrease even for small increases in temperature; for temperate zones, the response to CO_2 and moderate temperature increases will be positive.

- Climate change could cause significant disruptions of eco-systems; global timber supply is projected to increase.
- Coastal zones and marine ecosystems will be adversely affected, both by increases in sea surface temperature, sea level rise, and increasing storm frequency and intensity.
- For human settlements and the associated industry, the most widespread direct risk is flooding and landslides (due to increases in rainfall intensity); in coastal areas, sea level rise will be important.
- There will be diverse impacts on human health, mostly negative, such as infectious disease, air quality in urban areas, nutrition (food supply).

Adaptation

For water, numerous no regrets options exist which will generate net social benefit.

For ecosystems, adaptation in managed ecosystems may be possible, but adaptation to losses in wild ecosystems and of biodiversity may not be possible.

For human health, there will be a need to rebuild (or further develop) public health infrastructure

Vulnerability

From observation, physical and biological systems have already been impacted in the 20th Century, but the separate effects of climate change, and population and land use changes, are difficult to determine.

At small increases in temperature, aggregate impact could be plus or minus a few percent of GDP. At higher temperatures, the net change in economic welfare becomes negative.

3. Mitigation

The key findings are that:

- progress with developing technologies for reducing GHG emissions has been faster than anticipated,
- by 2020, half of the potential emission reductions may be achieved with direct benefits exceeding direct costs; the other half can be achieved at a net direct cost of less than US$100/tC (1998$),
- with emissions trading internationally, the marginal costs of carbon emissions reduction are reduced from a range of US$20-600/t C to US$15-150/t C (1998 $)

For stabilisation of the atmospheric CO_2 concentration at 450 ppmv, Annex 1 countries (such as Australia) after 2012 will have to reduce GHG emissions beyond their Kyoto commitments; this is not needed if stabilisation at 550 ppmv or higher is acceptable.

Average global CO_2 emissions grew at 1.4% annually in the 1990s, *cf* 2.1% annually in the 1970s and 1980s.

Impacts on the Energy Sector

There are few comprehensive studies on the sectoral effects of mitigation. However, the energy intensive sectors will face higher costs, and accelerated technical change.

While coal will remain one of the major global and long term energy resources, the coal industry faces almost inevitable decline in the long term, especially in Annex 1 countries, and the removal of subsidies would result in a substantial reduction in GHG emissions. However, some technologies under development (*e.g* sequestration) could maintain the use of coal whilst avoiding net GHG emissions.

For oil, studies show a net growth in production and revenue until at least 2020. Although the industry faces a potential relative decline, this may be moderated by lack of substitutes for oil in transportation. The use of flexibility mechanisms will reduce economic costs to producers.

For natural gas, demand will grow at 2.6% per annum up to 2020, with most of the growth being in electricity generation (important for achieving Kyoto targets in some countries). There is unlikely to be significant use in the transport sector by 2020.

For electricity generation, policies on GHG emissions will drive the use of renewables, and lower GHG generation technologies (which includes increased energy efficiency in coal fired power generation)

Options

While there have been, and will continue to be, many new advances in technology, social innovation and lifestyle changes have the potential to make a significant impact.

Up to 2020 (at least), energy supply will be dominated by cheap and abundant fossil fuels, with natural gas playing an important role in emission reduction for electricity generation. Waste to energy, biomass and other renewable energy sources can make a significant contribution.

The potential reductions in global GHG emissions are 1900-2600 Mt C equivalent per annum in 2010, and 3600-5050 Mt C equivalent per annum in 2020; there is a high level of confidence in these figures.

In the *transport sector*, hybrid (petrol-electric) vehicles are available commercially, with major improvements, > 50%, in fuel economy. Fuel cell vehicles are expected to be introduced in 2003. It is expected that biofuels may play an increasingly important role.

For *industry*, improvement of energy efficiency of industrial processes is the most significant option for lowering GHG emissions. Significant technology is available to reduce GHG emissions from industry in most developed countries by 2010.

Material efficiency improvement (recycling, improved product design, material substitution) is an important option for reducing GHG emissions.

Comments on specific industry sectors are given below:

- In the *building sector*, substantial opportunities exist for reducing energy consumption and GHG emissions, most of which could be implemented at a negative direct cost of avoidance; substantial marketing and standardisation is required to overcome barriers to the application of integrated design and technology.
- For *iron and steel*, substantial annual savings can be made by applying existing or emerging technologies (*e.g.* smelt-reduction)
- In *agriculture*, significant abatement of the major sources of GHG emissions (methane and nitrous oxide) requires changes in agricultural practices, such as rice paddy management, improved fertiliser use (incl. slow release fertilisers), lower methane emissions from ruminant animals.
- In *electricity generation*, fossil fuels will continue to be dominant, contributing 37.5% to overall global C emissions. Options for improvement include greater use of combined cycle gas turbines, advanced coal technologies, and distributed power supply based on renewable energy sources.
- For *renewable energy*, their share of the market is expected to increase significantly from now to 2020, as the learning curve reduces costs and existing generation plants require replacement By 2010, cofiring of coal with biomass, gasification of wood, more efficient PV, offshore wind farms and biofuels will be more capable of market penetration.

Natural processes of sequestration have either a limited ability to mitigate GHG emissions, or there are outstanding issues to be resolved.

Biological mitigation (100 Gt C cumulative by 2050) can only take up 10-20% of projected fossil fuel emissions during that period. Biological sequestration may be in competition with other land uses, and sufficient land and water is not always available; a strategy needs to be developed. Costs of biological carbon mitigation options are quite low, although costs will increase as the opportunity cost of land rises.

Marine ecosystems may enable CO_2 to be removed from the atmosphere and transported to the deep ocean (a 40,000 Gt C reservoir). There are some concerns with the permanence, and consequences.

Barriers, Opportunities and Market Potential

The general barriers include uncertainty, unstable economic conditions, vested interests, lifestyles and consumption patterns that are difficult to change.

In the *building sector*, barriers include a lack of skills and incentives, market structure, and social issues. For large buildings (high cost investments), a number of energy efficiency incentives, with top down policies from government, may be required.

In the *transport sector*, an integrated approach is required to town and transport planning, with lifestyle changes to switch from private vehicles for commuting. Policies protecting road transport interests are a large barrier to change.

For *industry*, cost effective energy efficiency measures are often not implemented (due to competing investment priorities, lack of skilled personnel, inter alia). In the electricity sector, deregulation of the market has shifted fuel and technology to natural gas and oil fired power generation, away from renewables.

In *forestry and agriculture*, technologies are required that suit local conditions, and there is a need for adequate research capacity. Input subsidies distort markets. In addition, forestry faces a range of regulations and policies that favour alternative land use.

Policies, Measures and Instruments

The 3 international policy instruments defined by the Kyoto Protocol – International Emissions Trading (IET), Joint Implementation (JI) and Clean Development Mechanism (CDM) – provide opportunities for Annex 1 countries to fulfil their commitments cost effectively.

(Note: Companies can utilise these mechanisms to reduce their overall exposure to greenhouse emission liabilities. This will be considered in a separate study by CCSD Program 1)

Economics

To fulfil Kyoto commitments, modelling has shown that the Marginal Abatement Costs (MACs) for GHG emissions vary significantly, and are reduced if emissions trading is undertaken. These costs range from US$20-665 (1990 $)/t C without trading, to US$14-135 (1990 $)/t C with Annex 1 trading, and US$5-86 (1990 $)/t C with global trading. In addition, there are no regrets measures, which have negative MACs, *i.e.* are economic in their own right.

Expressed in GDP terms, the corresponding costs to meet the 2010 Kyoto target are:

- 0.05% - 1.14% with Annex 1 trading, and
- 0.01 – 0.67% with global trading

Beyond Kyoto, the reductions in GDP depend on the CO_2 stabilisation concentration chosen, and the emission scenario. At a 550ppm stabilisation level, the GDP reduction in 2050 ranges from 0.1 – 1.8%, depending on the scenario.

Future Work

A number of activities were identified, including technological and social innovation, analysis methodologies and evaluation of mitigation options. Region specific, sectoral studies of mitigation potential were also recommended.

4. Key Implications for the Coal Industry

From the TAR, there are a number of important findings relevant to the coal industry:

- The link between climate change and human activities is emerging from the background “noise”
- The impact of the climate change issue on the coal industry is generally adverse, although coal will continue to be a major energy source for the world for the foreseeable future. The fuel mix will change over a long transition period (30-50 years)
- The technology for mitigation is developing faster than expected

There are several implications for the Australian coal industry:

- Customers may require coal quality changes to produce less GHG emissions per unit of energy used
- Engagement in flexibility mechanisms on a worldwide basis will be of particular relevance to coal companies, in particular for those with operations (not just coal production) in both Annex 1 and Non Annex 1 countries.
- If there is “leakage” of high energy industry operations (*e.g.* aluminium production) to Non Annex 1 countries, the use of coal in Australia (*e.g.* for electricity generation) will be reduced.