Department of Resources, Energy and Tourism

PROJECT FINANCE FACILITATION

Prepared for the Carbon Storage Taskforce

28 May 2009

Contents

1 Executive summary

At the 2005 Gleneagles Summit, the G8 leaders strongly acknowledged the challenges presented by climate change and the clear linkages between greenhouse gas mitigation, clean energy and sustainable development.

The G8 leaders adopted a plan of action in response to these three, intertwined issues and tasked the International Energy Agency (IEA) with advising on alternative energy scenarios and strategies. The IEA program has six broad areas of focus one of which is the development of commercially viable CCS at scale. Australia has been closely involved in the development of CCS with the creation of a CRC, demonstration projects and most recently Prime Minister Kevin Rudd's announcement a $100 million Global Institute to accelerate the development of carbon capture and storage technology.

Australia's dependence on fossil fuels in the energy sector is a major contributor to the high greenhouse emissions intensity of our economy. Reducing our emissions intensity will require a major shift in this sector to low-emissions technologies.

Australia faces challenges in making substantial reductions in either emissions intensity or gross emissions. Addressing the technological makeup of the energy sector and a number of industrial processes is a particular challenge given the technological trajectory in these sectors to date.

Carbon capture and storage (CCS) offers the potential to address some of these challenges. However, CCS remains an immature and highly capital-intensive suite of technologies. Future CCS projects will face significant hurdles particularly with regard to obtaining appropriate project finance. The IEA has identified a number of challenges to commercial, large-scale deployment of CCS. [1]

The Department of Resources, Energy and Tourism (DRET) established a Carbon Storage Taskforce (the Taskforce) to advise the Commonwealth Government on CCS. The Taskforce recently held a one-day project finance workshop as part of its consultation process to assist in the identification of issues likely to impact the ability of CCS projects to obtain project finance. The workshop was held on 14 May 2009 and participants included key representatives from the finance sector, relevant industries and government departments. Deloitte facilitated this workshop.

The workshop was designed to assist in the identification of major issues likely to impact the ability of CCS projects to obtain project finance, understand the significance of these risks and suggest actions that would reduce risk and increase the attractiveness of investment in CCS projects. Focusing on three case studies, the workshop explored these issues. Key risks identified during the workshop included policy uncertainty, risks "concatenating" across the elements of the CCS system (capture, transport and storage), risks with the new elements of CCS technologies, competing low-emissions technologies, the size of the required investment and public acceptance.

All participants concurred that there was an important role for government to assist in managing risks that would otherwise present substantial barriers to the viability of any future CCS projects at all stages of the CCS process – capture, transport or storage.

[1] International Energy Agency, *CO2 Capture and storage: a key carbon abatement option*, 2008.

2 Workshop summary

2.1 Workshop objectives

The major non-technical challenge for accelerating the deployment of CCS at commercial scale remains the uncertainty surrounding the potential for CCS to provide a commercially viable proposition for GHG emissions mitigation.

An important role will always remain for government in facilitating CCS by establishing a robust and credible legal and regulatory framework for the capture, transport and storage of CO2 and an effective carbon price.

However, a level of risk remains in respect of commercial scale projects, which the private sector may find unacceptable. The private sector is unlikely to commit to financing the construction of CCS projects at the scale required by the G8 plan of action until the uncertainty as to whether the facilities will present a commercial proposition is resolved. This uncertainty will remain until the cost of CCS technology has been proven.

This difficulty can be illustrated via the concept of the innovation chain in the gap between proof of concept at an R&D level to full commercialisation and diffusion, referred to as the technology 'valley of death'.[2] This is particularly relevant to CCS, given the immense costs and hence risks of establishing the required infrastructure.

Technology, regulatory (including carbon price), and community perception risks all impact on investment decisions for CCS projects. Calculation of costs (overnight or LRMC) for CCS will remain subject to a reasonably high degree of uncertainty for quite some time and this exposes providers of debt and equity capital to risk. Perceived risk influences the value of one of the important parameters: discount rate. Uncertainty also affects the comparison of costs from one investment with another. estimates of costs will distinguish between capital costs and operating costs, and identify their key components separately. For power plant applications, estimates of levelised costs will also be included.

The primary objective of the workshop was to identify major issues likely to impact the ability of CCS projects to obtain project finance, understand the significance of these risks and suggest actions that would reduce risk and increase the attractiveness of investment in CCS projects. Specifically, DRET sought the following outputs from the workshop:

- identification of the key risks affecting investment decisions for carbon capture and storage (CCS) projects
- analysis of the risks attendant on each of those factors (likelihood and consequence)
- evaluation of the acceptability of these risks and whether the market could bear the required investment return expected as a result of the unmitigated risks
- identification of potential risk mitigation strategies involving either public or private sector action.

2.2 Workshop approach

The one-day workshop focused on project finance risk identification, evaluation and mitigation, based on three case studies with a diverse group of government policy makers, financiers and power and oil/gas industry experts. Sessions during the day included the following elements:

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[2] M. Grubb, 'Technology Innovation and Climate Change Policy: an overview of issues and options', *Keio Journal of Economics*.

- *case studies*: three case studies were used to focus participants on concrete project finance risks for capture, transport and storage. The case studies assumed first-of-a-kind commercial projects had demonstrated technologies somewhere in the world – but that the projects were the first implementation in Australia. Capture technologies were only considered for electricity generation. Information was provided on technological maturity and estimated LRMC
- *risk identification*: group identification of risks with the potential to affect private-sector investment in CCS projects – capture, transport and storage
- *risk evaluation*: group evaluation of risks (likelihood and consequence) as well as an assessment of uncertainty of the group assessment based on available information.
- *analysis of risk and return*: group analysis of the return required to invest in the unmitigated risk, and whether a commercial investor would consider the project at any conceivable rate of return.
- *risk mitigation*: group analysis of mitigation strategies to mitigate risks that could be undertaken by the private sector, government, or both.

2.3 Workshop participants

The workshop participants were from a diverse group consisting of senior representatives from the finance sector, project finance, industry associations, insurance companies, government departments and members of the taskforce.

The table below indicates participants who attended the workshop.

Participant	Organisation
Andy Rigg	CS Taskforce
VJ Satkunasingam	ANZ
Brian Johnson	PriceWaterhouseCoopers
Angela Karl	UBS
Nick Cleary	Westpac Corporation
Burt Beasley	Australian Coal Association
Tony Wood	Clinton Foundation
Brad Mullard	Department of Primary Industries (NSW)
Stuart Booker	Department of Employment, Economic Development and Innovation (Qld)
Richard Aldous	Department of Primary Industries (Vic)
George Mudrinica	Zurich Global Energy
Sally Aitken	Macquarie
Peter Cox	Worley Parsons
Chris Spero	Callide Oxyfuel
John Torkington	Chevron

Participant	Organisation
Lewis Jeffery	Hydrogen Energy
Chris Kendall	International Power
Scott Hargreaves	Monash Energy
Mike Congreve	Santos
Alf Garnett	Schlumberger
Chris Greig	Zerogen
Keith Spence	CS Taskforce
Peter Wilson	Department of Resources, Energy and Tourism (C'th)
John Burgess	CS Taskforce
Bill Koppe	AngloCoal
John Pegler	Australian Coal Association
Phillip Mak	NAB
Nick Sankey	CBA
Larissa Cassidy	CS Taskforce
Meredith Dinneen	CS Taskforce
Bruce Godfrey	NLECC
Ric Simes	Access Economics

3 Workshop outputs

3.1 Risk identification summary

Despite the diversity of workshop participants, a consistent outline of the major risks emerged from the workshop.

- ***policy uncertainty*****:** the lack of a strong, consistent policy framework for reducing emissions and the consequent uncertainties about an emissions price and the impact on project returns was the major risk identified by all participants; specific elements of this risk discussed by participants included:
    - final CPRS caps and rate of reduction
    - CPRS market volatility
    - long-term depression of permit prices due to CDM imports.
- ***"concatenating" risks*****:** successful CCS requires a integration of each of the major components (capture, transport, storage), risks are chained together and have the potential to reinforce each other in unexpected ways, this constrains investors' ability to manage risk and increases the complexity of risk management and the cost of bringing risks down to an acceptable level
- ***systems integration:*** the "chicken/egg problem", financing for each component (capture, transport, storage) dependent on the likelihood of successful implementation of the others; policy uncertainty increases the risk of finding foundation customers and makes investment in each "component" difficult
- ***"contractual" integration:*** integration risks and concatenating risks were seen to significantly increase counterparty risk and contractual complexities; in addition, differing (and perhaps irreconcilable) objectives of capture, transport and storage project proponents were raised as an issue in the design of the contracts that would permit CCS development to occur. One participant raised the example of a generator wanting to be able to modify the amount of CO2 captured for transport and storage – and consequently the parasitic load – depending on the carbon price, while transport and storage operators were likely to require take or pay contracts that would limit generator flexibility to manage carbon costs
- ***technology risk*****:** even in the context of case studies where projects were not "first-of-a-kind", technical risk remained a significant issue. Technology risks included:
    - uncertainties surrounding size of parasitic load for capture technology, overall efficiency and outage rate for plant with capture technology, optimal plant size and project life
    - expectation of breakthrough in low carbon generation leading to delay or indecision
    - optimal pipe diameters and materials for transport network
    - transferability of oil and gas experience to carbon storage reservoir exploration, assessment and long-term management
    - ability to access insurance for technologies without a longer implementation history.
- ***competing technologies and the size of investment:*** the highly capital-intensive nature of CCS led to concern about the risk of alternative abatement options (from wind to nuclear to distributed generation) making CCS uneconomic
- ***early obsolescence:*** new CCS technology developments damaging the economics of early CCS projects. While project financiers needed to estimate the costs of each current project, in evaluating risks they also needed to consider early obsolescence the likely costs of the second

generation projects that might flow from them and compete during the lifetime of the earlier project. This risk was linked to systems integration risks with participants considering it likely that some CCS capture projects might be delayed as investors waited for lower-cost capture innovations to prove themselves overseas with significant flow-on effects to transport and storage participants.

- ***Public acceptance*****:** a major risk identified by all participants, with the impact of an early "accident" considered to be extreme.

For a summary of risks raised see appendix A. For a detailed list of all risks, see appendix C.

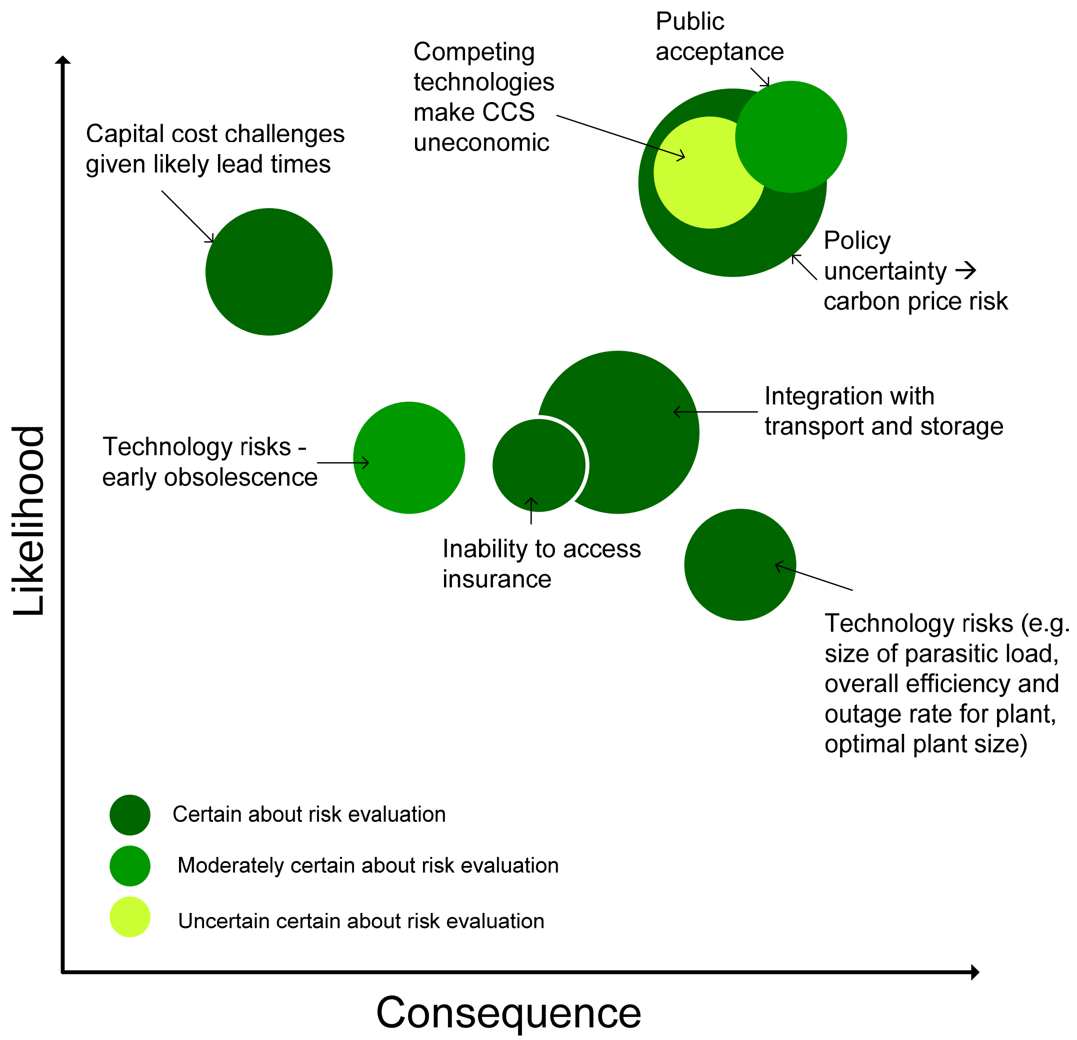
3.2 Risk evaluation summary

Each participant was asked to ‘vote’ for the top ten risks associated with the case studies. Participants were asked to select risks for evaluation and assess: (a) the likelihood of the risk occurring, (b) the consequence of the risk to the future viability of any CCS project and (c) the degree of certainty participants judged they were able to make about assessments (a) and (b). The results from each group have been aggregated and plotted on the bubble chart. below. The size of each ‘bubble’ represents the number of votes that particular risk received from participants.

Participants plotted risks against likelihood and consequence scales that ranged from “highly unlikely”/“no impact” to “certain”/“severe impact”. The highest impact risks were judged to be those that would cause CCS projects to fail or not occur.

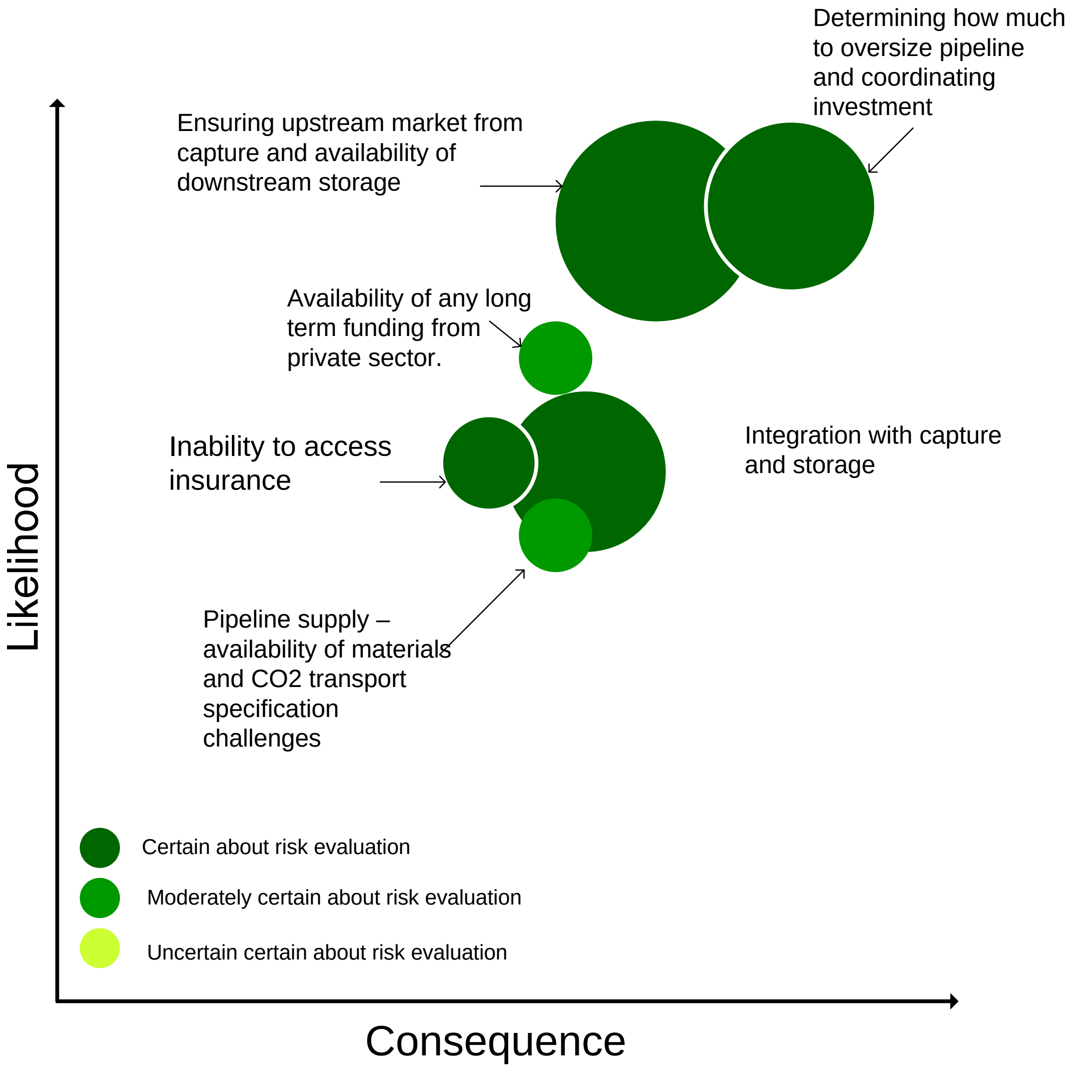
Due to time limits, not all risks were evaluated. Each group chose a selection of risks they felt were particularly important. (For a more detailed list of risks raised refer to appendix A and C.)

3.2.1 Capture risk (electricity generation)



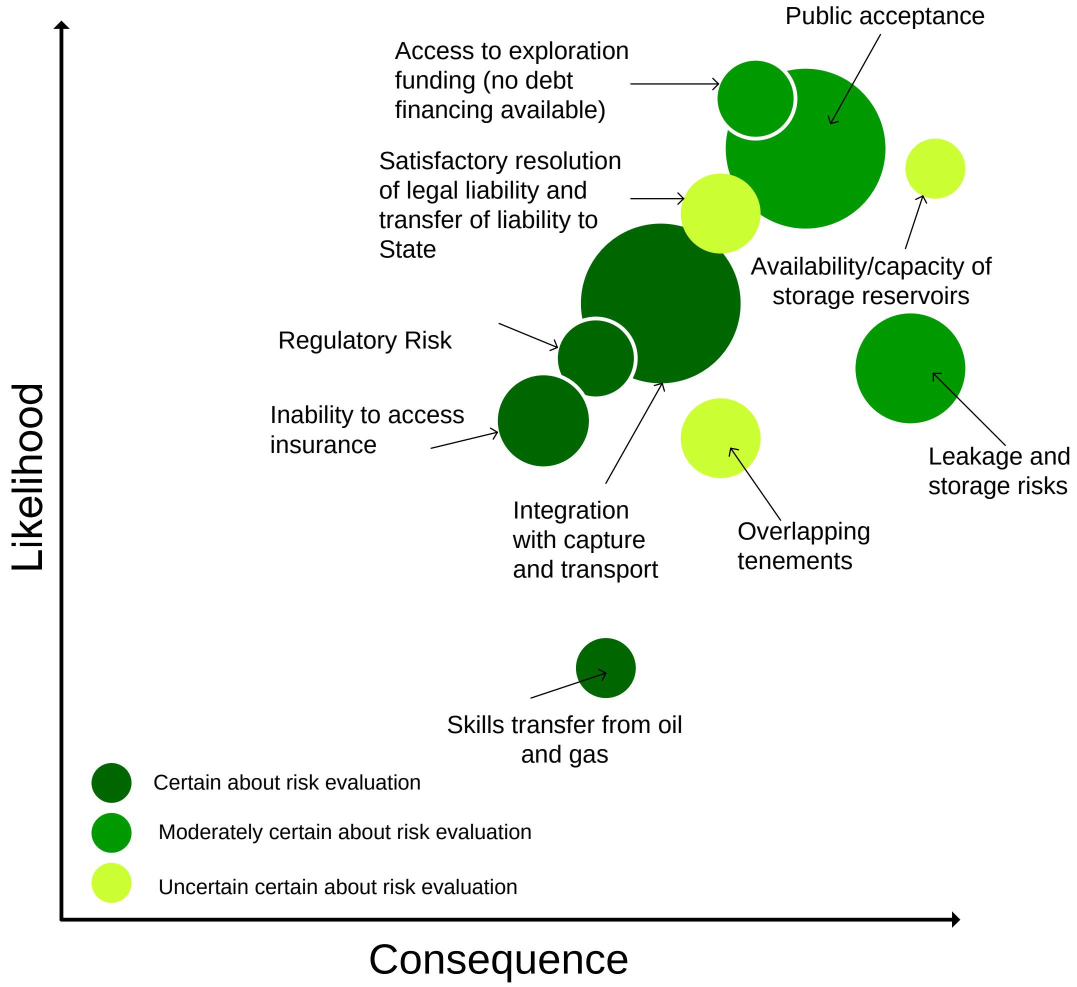
The selected risks for generation had a greater spread than for the other two stages of the CCS chain. Policy uncertainty was the risk of most concern to participants by far.

3.2.2 Transport risk



Ensuring upstream market from capture and the availability of downstream storage was a major risk identified by the group. Although the group believed there was a high likelihood of the risk occurring, the consequences for CCS were not judged to be as severe as for some of the other risks identified across the CCS chain.

3.2.3 Storage risk



Public acceptance of storage of CCS was of concern to a large number of participants, and the groups identified this risk as have a major consequence on CCS being under taken.

3.3 Can the market bear the risk?

In a number of cases, participants came to the conclusion that the risk identified or the level of uncertainty was so high that the market could not bear it and investment would not occur at any level of return. In particular, policy uncertainty was seen to be a risk that would prevent investment unless resolved. Similarly, community acceptance was seen to be a necessary requirement for financing of CCS projects.

Where other risks might be accepted by the market provided returns were sufficiently high, it is likely that the return required would be too great for projects to be viable under any of the current carbon price projections available for the CPRS.

3.4 Risk mitigation summary

Groups workshopped a number of key risks and identified a series of mitigation strategies that could lower levels of risk or uncertainty. Some of the strategies involved suggestions on how the private sector and financiers would mitigate risks, but the majority of key mitigation strategies involved government and regulatory responses.

The government and regulatory mitigation options fell into the key areas of establishing policy certainty for long time periods, establishing appropriate legal and regulatory frameworks for CCS and electricity prices and financing some elements of infrastructure construction.

Individual participants did not necessarily agree that all mitigation strategies were sensible options from a public policy perspective. A number of participants remarked: “this is poor policy, but necessary for successful CCS.

Policy and cost uncertainty

- ***Carbon and electricity price*****:** Most groups indicated that the market would struggle to deal with this risk at any price. A number of alternatives were suggested and included delaying the project or the government manipulating the carbon price or mandating CCS technology. Either way, there was a strong view that government should provide a certain, long-term policy framework around carbon markets if CCS was to be successful.

- ***Uncertain revenue:*** The level of uncertainty in revenue projections for CCS projects was seen as much higher than for other infrastructure or large-scale technology investments. This uncertainty increased the challenges for project finance. Participants suggested that options to address this uncertainty included take or pay contracts, government underwriting electricity and carbon transport/storage prices (with a profit sharing arrangement), or Government financing infrastructure construction – particularly in relation to the pipelines network for transport. There was a widely-held view that government will need to take an active role in facilitating and finance CO_2 pipelines for a ‘backbone’ network to ever be constructed.

- ***Legal and liability issues:*** Current laws and regulations will need to be clarified for CCS to become viable. Some of the options that were identified was to ensure there were clear technical regulations, a clear liability framework (perhaps limited/or with a government indemnification) or establishment of a industry fund through the use of a remediation/environmental bond.

Technology risk

- ***Technology risk:*** Although there have been a number of successful pilot projects around the world, CCS technology remains immature. This risk could be mitigated to some extent with a successful large scale demonstration plant. Government clearly had a role to play in assisting the financing of demonstration projects. However, even with successful demonstration the level of technical risk remained high and the consequent level of returns required remained high.

- ***Getting pipeline sizing:*** *C*reating the optimal pipe size was seen to be an important requirement. The key mitigation strategy is to for there to be some contractual certainty, policy certainty for capture and storage participants to ensure a broad foundation load and also a regulated return.

Competing technologies and the size of investment

- ***Alternative abatement technology*****:** Given abatement technologies are moving fast, cheaper abatement technologies could make CCS less viable. Mitigation strategies include power purchasing agreements, mandating that energy generators achieve a required output or having a feed in tariff for CCS.

Public acceptance

- ***Social license to operate:*** Participants believed that receiving public confidence was essential for CCS to be successful. Mitigation strategies included ensuring sound engineering and quality assurance processes, a public education campaign (similar to the black balloons campaign) and ensuring appropriate safeguard regulations.

"Contractual" integration

- ***Inability to secure take or pay contracts:*** Suggested options included the Government underwriting contracts in the early days, commercialising pipeline and storage and shared ownership of plant, pipeline and storage.

Systems integration

- ***Integrated chains****: S*uccessful integration of the three stages was essential – from an operation point of view and certainty for construction. Suggested options included having capture ready plants in place, effective co-ordination amongst the 'actors' and having a Government BOO for the missing links.

Appendix A

Additional risk summary

Capture

Risk category	Summary of the risk
Technological	These risks all fell into the broad category of technological uncertainty given the immaturity of CO2 capture technology. In addition, the technological risks of the other stages of production – especially storage – impacted on the economics of capture.
Construction	With all infrastructure and technology projects there is a certain element of construction risk. However, in addition to these risks, participants also highlighted risks associated with this new technology including location uncertainties (Greenfield v's Brownfield), having to compete for skilled labour, siting issues and the availability of capital inputs.
Carbon Price	Given Australia does not yet have an emissions trading system in place (or another market mechanism to set the carbon price), there is significant uncertainty on what the future long run carbon price will be. The carbon price greatly influences the economics of CCS. This issue prompted significant concern among all of participants.
Regulatory Risks (electricity price regulation)	This issue was raised by a number of participants focusing on broader electricity market regulation and carbon price pass through. While legislation has been passed in Victoria to provide for full past through this has not occurred in other states.
Market Risks	Most of these issues were similar to those raised with carbon risk. Many participants highlighted that competing technologies could have an impact on CCS, particularly if lower cost abatement options became available.
Costs	There were many different type of risks indentified which fell under this category including relative costs of alternative abetment options (such as international trade in permits), insurance costs, operation costs, project life, operating expenses, economies of scale and the estimated terminal value of the project.
Public acceptance	Many groups highlighted the need for public acceptance for CCS to proceed.

Transport

Risk category	Summary of the risk
Technological	One of the risks raised by many participants was how do you set the optimal size of the pipeline undertaken by this project. Having a sub-optimal size will affect key financial decisions. Expansion for future capacity, force majeure, operational issues and capture ready signoffs were also raised.

Construction	A ready supply of pipelines will be an important input into the construction of the pipe. Given the world demand for pipes are high – particularly from water projects – there was concerns about the availability of this input into the project.
Carbon risk	The main risks identified were the integration risks and the impact a carbon price would have on capture project viability.
Regulation/Policy	The ownership structure of the pipeline was an important decision to get right. Should the government build it, should it be a public private partnership and/or should it be a regulated monopoly? There was a strong view that like other distribution assets, it was necessary that the infrastructure had monopoly protection.
Market Risk	This also related to complimentary risks. The shared pipeline could technologically commence earlier than the other projects, but there needed to be some certainty that there was a market for CO2 to be sequested and stored.
Costs	Scheduling costs were raised by a number of participants. There is very little/almost no experience in this field which will result in large legal and financial advisory costs. Other cost risks were raised, such as the ability to undertake insurance and the powering of the pipeline.
Public acceptance	As with capture and storage, it was seen that public acceptance was a pre-requisite for CCS

Storage

Risk category	Summary of the risk
Technological	This was raised by many participants. Given the technology is very new, many participants were concerned by potential leakage and the catastrophic consequences resulting from this. There were many questions about how storage would work – such as availability of storage and future expansion, long term pressure behaviour, each reservoir's characteristic and overlapping tenements.
Regulation/Policy	Given this a new technology, regulatory risk is always higher. The potential for multiple regulators across all levels of government was seen to be a particular risk.
Market Risk	There was concern about labour market risk and skill transfers/competition with the oil and gas industries. There was also a lot of discussion about take and pay contracts and generator's desire to be able to modify emissions depending on carbon prices.
Costs	The sort of costs raised were ongoing development costs, insurability, contracting arrangements and a tighter project life. Concatenating risks across all three technologies was also a concern – given that the risks associate which each technology greatly affect costs for each stage of the production.

Appendix B

Comparative technology risks for electricity generation

RISK ANALYSIS - NEW PLANT								
ITEM	GENERATOR						TRANSPORT	STORAGE
	IGCC CCS	Capture Ready IGCC	Natural Gas CCGT	Wind	Geothermal	Solar Thermal		
Technological risk								
Risk of technological failure	High	Moderate	Low	Low	High	Low	Low	Moderate
Performance risk	High	Moderate	Moderate	Moderate	High	Moderate	Low	Moderate
Construction Delay	Moderate	Moderate	Low	Low	Moderate	Moderate	Low	Moderate
Carbon price risk	High	High	Moderate	None	None	None	High	High
Fuel price risk	Moderate	Moderate	High	None	None	None	None	None
Fuel supply risk	Low	Low	High	None	None	None	None	None
Regulation risk								
Government Policy								
a. More/less stringent carbon caps over time	High	High	High	None	None	None	High	High
b. Favour other technologies	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Market regulations								
a. Dispatch rules	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	None	None
b. Network pricing and access rules	Low	Low	Low	Moderate	High	High	High	High
c. Ancillary service requirements	Low	Low	Low	Moderate	High	High	High	High
Other regulations								
a. Local planning rules	Moderate	Moderate	Low	High	Low	Low	High	High
b. Environmental rules	High	High	Low	High	Low	Low	High	High
c. Rules governing CO2/waste storage	High	High	None	None	None	None	High	High
Market risks								
Price trends and volatility	High	High	High	High	High	High	Low	Moderate
Competitor cost trends after entry (volume risk)	High	High	low	Low	Moderate	Moderate	Low	Moderate
Ramp up risk	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate
Large Load Leaves	High	High	High	Low	Low	Moderate	High	Moderate
Breakthrough technologies down the track	High	High	High	Moderate	Moderate	Moderate	High	High
Transmission constraints	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate
Marginal loss factor adjustments	Moderate	Moderate	Low	High	High	High	None	None
Carbon transport cost risk	Moderate	Moderate	None	None	None	None	High	High
Storage cost risk (CO2 or waste)	High	Moderate	None	None	None	None	High	High

Table developed for workshop and updated with risk evaluation from workshop participants.

Appendix C

Consolidated list of risks with risk evaluation

Generation

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
Technological					
Long term pressure behaviour	Is there a water issue				
Availability of storage & cost expansion					
Learning curves					
Ability to develop confidence in reservoir performance required to support investment go ahead			4	10	2
Remaining uncertainties for Australian deployment	Uncertainties surrounding parasitic load, overall efficiency and outage rate for plant with capture technology, optimal plant size and project life	8	5,6,8,6	8,9,7,6 (7.5)	2
Construction					
Capital cost – lead times and delays	Difficult to estimate cost and timing of delivery of	10	8	3	3

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
	long-lead times and delays				
Siting issues	Compared to well known industries such as water and coal	2			
Capital cost – available of infrastructure		2			
Plant Delivery – vender risk		1			
Capital costs – contract	Can't access fixed price contract	1			
Location uncertainties	Where to locate. Greenfield v's Brownfield. Available locations are suboptimal on one or more of the following components: access to electricity grid, access to pipelines, distance to storage, access to fuel, access to ports/rail for transport of major components	1	9	4	3
Plant Delivery – skills	Skills will be in competition with CCGT and LNG		8,8	5,5	3,3
Carbon Price					
Price Risk – Electricity and CO2	Uncertainty in carbon prices and final electricity prices (differing state approaches to price regulation), Could also include international trade in permits and relative cost (abatement measures)	21	10,9,9,7,8	10,8,8,7,8	3,2,3,2,3
Falling demand because of high retail prices for low carbon electricity					
Revenue from CO2	Value added uses for CO2, practical realities				
Regulation/Policy					
Regulatory risks	Including approvals				
Market Risk					
Performance warranties					

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
Fuel risk	Black v's Brown Coal. Fuel matching, quality of coal compared to international experience.				
Costs					
Integration Risks	Risks associated with Transport and capture effect generation and mutatis mutandis for each other element, Failure of key links and integrated design risk. Integration between all three.	15	4, 5, 5, 6, 7, 9,7	4,5,7,8,9,10, 9	3,3,3,3,3,2, 2
Relative costs of alternative abatement options	Such as Nuclear, Wind Geothermal and Solar or second generation CCS.	8	9	8	1
New technology delays investment in any/all components	Expectation of breakthrough in low carbon generation leading to delay/indecision Early Obsolescence	8	4,9 (6.5)	3,6 (4.5)	2,3
Insurance	Not being able to insure	6	5,4 and 9	5,6 and 7	2,3 and 3
Operations	Predicting operating availability. Low confidence in plant performance	6			
Counterparty risk	Segregation of liability	5			
Project Life	Financiers will want project life to be shorter	5			
Scheduling – demands for pre-investment	This stretches timeliness and required payback period. Pre-investment costs are sunk.	2			
Operations - Shutdowns and maintenance	Uptime, extended shut downs, operating/maintenance requirements, workforce issues				
Operating Expenses	Including cost of capture				
Terminal Value	Will influence the debt;/equity equation				
Economies of scale	What is the right size of the plant?		2	2	1
No certainty of gross margin			9	9	3

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
Inability to convince financiers on revenue stream without gov't support			10	10	3
Public acceptance					
Having a social license to operate	Lack of awareness risk by all stakeholders	7	10	10	2

Storage

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
Technological					
Leakage and storage risk		8	6	10	2
Exploration	Who is going to fund it really?. Who funds the next stage. Cannot debt-finance exploration.	6	8,10,8	9,10,6	1,3,3
Overlapping tenements	Petroleum, Water, Geothermal and CSM	6	5	8	1
Environmental Risk		4			
Site closure cost		4			
Each reservoir characteristics		1			
Are there multiple options for CO2 storage	Supply and demand of storage				
Technology					
Residual storage risk					
Long term pressure behaviour	Is there a water issue				
Availability of storage & cost expansion					
Learning curves					

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
Ability to develop confidence in reservoir performance required to support investment go ahead			4	10	2
Regulation/Policy					
Public acceptance	Selection of location	13	6,6,8,8,9,10	7,7,9,9,10,10	1,1,2,2,3,3
Legal	Who owns the COS? Who carries the liability? Abandonment liabilities. Confidence Minister will grant final certificate extinguishing liability. Does the environmental bond displace liability?	6	7	8	1
Regulatory risk	Risk is always higher with new industries. Could be multiple regulators across jurisdictions.	5	3,3,8,9	4,6,6,9	2,3,3,3
Monopoly	Needs to be a monopoly with regulations to project it	3			
Regulatory monitoring requirements					
Market risks					
Availability and capacity	Capacity and injection rate uncertainty prohibits long term contracting	3	8	10	1
Skills transfer from oil and gas – labour market risk.	Inability to transfer storage technology / capability from Oil and Gas to CCS	1	3	6	2
Number of facilities	Exploration of Greenfield v Brownfield				
Take and Pay					
Demand for take or pay	From the source and to the pipeline				
Costs					
Integration Risks	Risks associated with Transport and capture effect	15	4, 5, 5, 6, 7,	4,5,7,8,9,10,9	3,3,3,3,3,2,2

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
	generation and mutatis mutandis for each other element, Failure of key links and integrated design risk. Integration between all three.		9,7		
Ongoing development costs		6			
Insurance	Not being able to insure	6	5,4 and 9	5,6 and 7	2,3 and 3
Performance		2			
Complementary Risks	Risks associated with Transport and capture effect generation, Failure of key links and integrated design risk	1			
Contracting	Power stations want multi-decade certainty. Opportunity for revisiting and review	1			
Project life is tighter					
Operating costs					
No business model					

Transport

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
Technological					
Sizing – how much do you oversize	Who would pay – how is investment coordinated. What is the right size?	13	8	7	3
Maintenance of CO2 at correct state	Expansion for future capacity, force majeure, operational issues, exposure to multiple projects, capture ready signoffs	3			
Routing issues	Easements/population. Can't route without knowing where the storage sites are	1			
Learning curves for cost					
Purity/dryness specs and costs					
Common risks	Across generation and capture				
Construction					
Availability of timing	Incremental expansion risks. First build risk	2			
Capital risk – who can supply pipes	Who can supply large diameter pipelines, stainless steel – are there specific CO2 requirements	2	5	6	2
Shared infrastructure		2			
Carbon					
Tariff cost for CO2		1			
Other uses for CO2					
Regulation/Policy					

Risk	Comments	Number of Votes	Likelihood	Consequence	Level of certainty
Ownership	PPP/Gov't/Private.	4			
Native Title		1			
Requirements for CO_2 seqs					
Access regime					
Competition	Has to be a monopoly				
Without government funding large volume pipeline networks will not be delivered			3	10	3
Market risk					
Volume	Early build. Capacity optimisation, redundancy	3			
Costs					
Integration Risks	Risks associated with Transport and capture effect generation and mutatis mutandis for each other element, Failure of key links and integrated design risk. Integration between all three.	15	4, 5, 5, 6, 7, 9,7	4,5,7,8,9,10, 9	3,3,3,3,3, 2,2
Scheduling	Time to negotiate agreements. Not much experience. Big legal/finance advisory costs. 1.5 to 2 years	6	8	8	2
Long term funding	No private investment for transport	3	8	6	2
Powering the pipeline		1			
Insurance	Not being able to insure	6	5,4 and 9	5,6 and 7	2,3 and 3
Operating	Variability and through put. Operating issues/revenue issues				
Project life	Tighter – tied to technology				
Public acceptance					
License to operate	Community acceptance	3			

Appendix D

Risk mitigation

Group 1

Risk	Party to bear	Mitigation Strategy	Can market bear the risk
Commercial development of large “backbone” pipeline network. It maybe that the shared infrastructure necessary to support the technology is not viable for a private sector party to build.	• Pipeline network owner	• Government mandate or alternatively a market base solution • Government underwrites % of surplus • Don’t build until contracts secured • Take or pay contract	Yes, provided there are some guarantees.
Real or perceived major CO_2 disaster destroys CCS. Given this is new technology and unproven, it will be a challenge educating the community about its safety. If this fails and there is wide-spread community opposition, CCS could fail to progress.	• Project proponent and Stakeholders	• Sound engineering/QA Process • Public education – no black balloons • Appropriate regulations	No.
Inability to secure take or pay contracts – Plant/Pipeline/Storage. Given the technology is new, project proponents will want some contractual certainty before investing.	• Plant, Pipeline and storage	• Government underwrites in early days • Commercialise pipeline and storage • Shared ownership plant, pipeline and storage	Yes, but potential returns would need to reflect the risk
Long-term price gap between electricity and cost of CCS	• Project proponent	• Effective Pricing Scheme (Government Support) – ie mandated arrangement	No. High relative cost of electricity will be the only way CCS will take off.

Risk	Party to bear	Mitigation Strategy	Can market bear the risk
(Stranded asset risk). The Treasury model suggests that a CPRS will cause minimal impacts on electricity prices in short-term. The business case for CCS will only work under high future electricity prices.			
Capture Technology reliability risk high. Although there have been a number of successful pilot projects around the world, the technology is still very new. If the technology fails, carbon will not be able to be captured on a commercial scale.	• Technology Provider (Project Owner)	• Large scale demonstration • Risk sharing between parties (General and technical) • Transitional compliance relief	No.
Lack of incentive for storage exploration delays – identification of sites. Exploration costs are high and are very difficult to fund – especially through debt. Finding the right type of storage facilities will be essential for CCS to work.	• Storage owner	• Build reliable data rooms(s) • Pre-competitive exploration and appraisal • (Government funded)	Yes, but returns would need to be very high.
Extended delays in "new project" approvals. Given all three parts of the chain are new technological advances, regulatory approvals are likely to be numerous.	• Project proponent	• Co-ordinate approval processes • Government agencies and appropriate resources	Yes, but returns would need to be high.

Group 2

Risk	Party to bear	Can market bear likely price	Mitigation
Electricity Price insufficient. The Treasury model suggests that a CPRS will cause minimal impacts on electricity prices in short-term. The business case for CCS will only work under high future electricity prices.	• Generator and its investors	• No – doesn't meet hurdle rate	• Delay the project • Market price has to be supplemented by government support mechanisms • Capture ready plants and gradual capture installation
CO_2 price insufficient to drive up take up of CCS. Similar to the above point, however, in this case a low CO_2 price will result in demand for lower cost abatement options at the expense of CCS.	• Generator • Storage owner/operator • Pipeline owner/operator (counterparty risk)	• No – doesn't meet hurdle rate	• Government manipulates Carbon price • Government mandates CCS for forensic penetration • Delay projects • Pre-investment to buy CCS option
Inability to get permitting completed (in absence of government intervention). Given this is new technology and unproven, it will be a challenge educating the community about its safety. If this fails and there is wide-spread community opposition, CCS could fail to progress.	• Storage owner/operator • Generator	• No	• Build community confidence by: o Flagship projects successful o Massive education/outreach campaigns o Costs drive projects through
Getting size of pipeline right. The size of the pipeline will greatly affect the cost of the building the project. Care would need to be given to what the optimal size of the pipeline should be. A larger than optimal pipeline will result in a too large build cost and possibly high operating costs. A smaller than optimal pipeline will make it difficult storage operators and generators.	• Pipeline owner/operator (transport)	• Yes	• Contract terms • Regulated return on asset base
CCS integrated chains not in place in timely manner. Each of the three stages is complimentary to each other. If there are	• Everyone in value chain and investors	• Yes – for a certain time at a premium,	• Capture ready plants • Coordination among "actors"

Risk	Party to bear	Can market bear likely price	Mitigation
delays or technical issues for one, it will have impacts on the others.		otherwise no	• Government Build/Own/Operate “missing links”
Confidence in overall project economics. Given the level of uncertainty in the technology and pricing of CO_2/electricity, it is difficult to have confidence in economics of the projects.	• All parties	• Yes	• Build flagship projects • Connecting strategies • Long term off-take and input supply contracts
Capacity to manage EPCs and contractor’s long-term capacity to deliver.	• All parties and EPC contractors	• Yes	• Build flagship projects • Connecting strategies • Internal project/contract management
Integration of whole value chain and its successful operation. This is **s**imilar to the above point. If the three technologies do not integrate well, each stages performance is affected.	• All parties and EPC contractors	• Yes	• Arrangements among actors in value chain interface management – contract performance guarantees
Ability to negotiate necessary agreements along value chain. In addition to needing successful integration, long term contracts between the three parties need to be entered into. As each stage has its own risks, each party will want to price risk into its contracts.	• All parties	• Yes	• Build flagship projects in Australia • Lessons from other industries • Allow appropriate time for agreements
Ability to lay off risks with insurance. Given insurance is one way of mitigating risk, failure by insurance companies to insure certain risks will result in the enterprise having to carry that risk themselves.	• All parties (hazards) particularly storage because new	• Yes (and decreases hurdle rates)	• Build flagship projects • Actuaries/insurers are educated/engaged/informed

Group 3

Risk	Party to bear	Mitigation Strategy	Can market bear the risk
Revenue for pipeline unclear. Revenue will be a function of the other stages of the production. Unclear expected revenue from operating the pipeline makes it difficult to invest in the project.	• Pipeline owners (debt and equity)	• Take or pay plus long term price • 60-80% capacity and upside • Government underwriting Price (but will want upside) • Residual risk – credit worthiness of generator • Government finances the build (including oversizing)	No – there will need to be some degree of confidence in revenue.
Alternative abatement technology are relative low cost. If the carbon price is low, or alternative technologies are cheaper, CCS will become less viable. Given that CCS is a relatively new technology and has moved fast, perhaps cheaper, alternative technologies come to fruition in the near future.	• Generator • Transporters • Storer	• Power purchasing agreement (Long term) • Feed-in tariffs • Restructure market pay to be there • Credit for early action	Yes – to some extent. Returns would need to be high.
Capacity and injection rate uncertainty. The capacity of storage facilities and the timing of injection will effect financial model for this stage. This is a technology risk that needs to be clarified.	• Storage (D/E) • Generator (D/E)	• Appraisal • Send or pay % take or pay • <100% rate • Contingent wells/sites	Yes – but 40% @ FID.
Forward curve electivity price uncertainty. The Treasury model suggests that a CPRS will cause minimal impacts on electricity prices in short-term. In addition, the medium to long term price will have	• Generator	• Regulatory certainty of carbon price v/s CPRS and renewables (MRET) • Reg uncertainty vis-à-vis licensing • Market 'pull' mechanisms (Government) • PPA (long term)	No

Risk	Party to bear	Mitigation Strategy	Can market bear the risk
an impact on the project.			
Overlapping tenements implications – resource conflict. In Victoria, legislation may change to allow tenements to be stratified.	• Storage • Other tenement holder • Government	• Cooperation agreement • Joint development agreement • Site selection • Regulatory process and legal process	No
Sovereign Risk. The is the risk that Governments may change the regulatory environment – including taxation, environment and propriety rights which will impact on the degree of certainty investors will have.	• Everyone	• Involve government in project • Political influencing • Enshrine in legislation • Project regs/project agreements • Fiscal agreements long term – eg NWS	Yes
Regulatory access regime for storage and pipeline. It maybe necessary for the storage and pipeline stages to have a regulated access regime to give more certainty to generators.	• Storers • Transporters	• Access regime and details (REG) pre-FID	No
Conditions on transfer of liability (LT) to state and Commonwealth not clear. There are issues relating to who has legal responsibility for CO2 during the generation, distribution and storage. Does liability shift at different stages =and does it transfer to or from governments.	• Owner of CO2 • Storer	• Site selection and appraisal • Government indemnification as much as P? • Clearer technical regulations • Insurance • Remediation funds/bonds/industry fund	Yes