Council of Australian Governments (COAG)

CONSULTATION REGULATION IMPACT STATEMENT

DRAFT GUIDING REGULATORY FRAMEWORK FOR CARBON DIOXIDE GEOSEQUESTRATION

Prepared by Department of Industry, Tourism and Resources

INCLUDES:

1 INTRODUCTION

In the absence of a predictable and transparent regulatory mechanism, and uncertainty as to the adequacy or otherwise of generic regulatory processes, the Ministerial Council on Mineral and Petroleum Resources established a Carbon Dioxide Geosequestration Regulatory Working Group, in September 2003. The Regulatory Working Group was tasked to report to the Standing Committee of Officials of the Ministerial Council on Mineral and Petroleum Resources.

The Regulatory Working Group was chaired by a representative from the Western Australian Department of Industry and Resources. Other members included government resource sector representatives from the Commonwealth, South Australia, New South Wales, Queensland and Victoria. Tasmania and the Northern Territory participated by correspondence. There were also members from non-resource sector agencies with an interest in carbon dioxide geosequestration, such as the Queensland Department of Innovation and Information Economy, Department of Environment and Heritage, Australian Greenhouse Office, and the Department of Foreign Affairs and Trade.

A broader Carbon Dioxide Geosequestration Regulatory Reference Group, comprising all Working Group members as well as industry and research organisations, was also established to provide advice to the Regulatory Working Group. A set of draft regulatory guiding principles for carbon dioxide geosequestration were developed by the Regulatory Working Group for consideration by Ministers. These draft regulatory guiding principles are at Attachment A.

Broader consultation with the community, including non-government organisations will now be undertaken and this consultation process will give all interested parties the opportunity to be involved in the possible revision of the draft regulatory guiding principles. Input can be provided by attending workshops and submitting written comments in relation to the draft regulatory guiding principles.

It should be noted that this Council of Australian Government Regulatory Impact Statement is only concerned with a draft regulatory framework for carbon dioxide geosequestration. Significant work is being done on technological issues separately (i.e. not under the Ministerial Council on Mineral and Petroleum Resources), and as these begin to be solved, progress on legal and regulatory issues will be required, if only in the first instance by creating an enabling framework for consideration and facilitation of projects.

2 BACKGROUND

Energy and Greenhouse Gas Emissions

On 8 June 2001, the statement on Energy Policy from the Council of Australian Governments said that the energy sector, both stationary and transport, provides an essential underpinning of Australia's economic, environmental and social goals. Competitively priced and reliable energy services are a key part of our international industry competitiveness and standard of living. The Council of Australian Governments went on further to say that, Australian energy demand is growing rapidly, but at the same time energy supply and use is a significant source of greenhouse gas emissions.

In 2002, greenhouse gas emissions from the energy sector made up 68 percent of national greenhouse emissions as it is primarily dependent on fossil fuels. Carbon dioxide geosequestration, also known as carbon dioxide capture and geological storage, is one option in the medium term to reduce greenhouse gas emissions into the atmosphere from stationary energy sources.

The electricity generation sector which represents 33 percent of emissions is well placed to take advantage of carbon dioxide geosequestration technologies given that it is dominated by relatively few large emission sources. Other industry sectors, such as certain forms of chemical manufacture (including natural gas processing), the cement industry and aluminium production, all of which have large point sources of carbon dioxide, may also be able to utilise carbon dioxide geosequestration in reducing their greenhouse gas emissions.

Carbon dioxide geosequestration provides one of several options in the medium term to meet the objectives of sustainable energy use, lowering greenhouse gas emissions and utilising Australia's competitive advantage in low cost and abundant fossil fuels (coal and gas). Carbon dioxide geosequestration may present a practical, cost effective and hence viable option to Australia's greenhouse emissions out to 2030. It may provide a major role in enabling Australia to contribute meaningfully to achieving the international goal of stabilising greenhouse gas concentrations in the atmosphere, while maintaining our international competitiveness and economic growth.

Geosequestration – One of a Suite of Technologies

Geosequestration is one of a suite of possible technologies that the Australian, State and Territory governments are considering to enable Australia to meet future greenhouse constraints. Other options for reducing greenhouse gas emissions are likely to encompass end use efficiency programs, fuel switching, advanced renewable energy and other clean fossil fuel technology. Policies based on any one of these measures however, may not be enough to achieve sufficient reductions in carbon dioxide emissions.

Rapid change to non-fossil energy sources is unlikely according to the International Energy Agency's World Energy Outlook 2002, which projects global energy use to grow by two-thirds from 2002 to 2030, with fossil fuels meeting more that 90 per cent of that increase. This forecast of continued reliance on fossil fuels is based on the view that unless there is unforseen 'step change' in technology development costs, moving away from reliance on fossil fuels will have increase costs to the economy and energy security significantly.

It is recognised that given Australia's high level of fossil fuel resources, we can be expected to remain substantially reliant on fossil fuels for energy needs for the foreseeable future. For example, in the transition to a hydrogen economy, carbon dioxide mitigation will be required as hydrogen will be sourced mainly from fossil fuels.

The choice of greenhouse gas mitigation technologies is between low and high emissions outcomes – not between renewables and other energy sources. For example, in the Australian Government's recent Energy White Paper *Securing Australia's Energy Future*, the Government's current and future commitments to renewable energy and low emissions technology include:

- The Mandatory Renewable Energy Target will continue until 2020, providing incentives for over $2 billion in renewable energy investment;
- $14 million will be used to develop and install systems to provide accurate long-range forecasts for wind output;
- The new $500 million Low Emissions Technology Development Fund will provide support for low emissions technologies with significant long-term abatement potential;
- $75 million allocated to Solar Cities trials will directly support focused uptake of solar electricity and hot water as well as energy efficiency and efficient pricing signals; and
- $230 million was also included for the Australian Greenhouse Office to continue support for greenhouse technology projects under programs such as the Remote Renewable Power Generation and Greenhouse Gas Abatement programs.

Internationally - Carbon Sequestration Leadership Forum

Australia is contributing internationally to consideration of carbon dioxide geosequestration by being an active member of the Carbon Sequestration Leadership Forum. The Carbon Sequestration Leadership Forum is an international climate change initiative that is focused on the development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage. The purpose of the Carbon Sequestration Leadership Forum is to make these technologies broadly available internationally; and to identify and address wider issues relating to carbon dioxide geosequestration. This could include promoting the appropriate technical, political, and regulatory environments for the development of such technology.

The charter of the Carbon Sequestration Leadership Forum establishes a framework for collaboration between governments, industry, researchers, and non-government organisations in sixteen countries and the European Commission. They are: Australia, Brazil, Canada, China, Colombia, European Commission, France, Germany, India, Italy, Japan, Mexico, Norway, Russian Federation, South Africa, United Kingdom, and United States.

In June 2003, at the inaugural meeting of the Carbon Sequestration Leadership Forum it was agreed that a Legal, Regulatory and Financial Issues Taskforce be established. One of the key priorities in the short term is the development of international regulatory principles for carbon dioxide geosequestration. Australia was nominated to take the lead on the Task Force and in November 2003 hosted an international sequestration regulatory workshop with eight of the then fifteen member countries of the Carbon Sequestration Leadership Forum. The purpose of the workshop was to share information on carbon dioxide geosequestration, particularly on regulation and to discuss an approach and proposed timeframe to address regulatory issues.

Australia presented a discussion paper to the Carbon Sequestration Leadership Forum Policy Group in January 2004 in Italy, which proposed a case study and gap analysis methodology to identify and prioritise key international regulatory processes and gaps. The paper was well received by Carbon Sequestration Leadership Forum member countries and it was agreed that the approach proposed in the paper would form the basis of a work program on legal, regulatory and financial issues relating to carbon dioxide geosequestration. In particular, a set of international best practice regulatory principles were drafted for consideration by Carbon Sequestration Leadership Forum member countries at the second Ministerial level Forum meeting in September 2004 in Melbourne.

The Carbon Sequestration Leadership Forum Legal, Regulatory and Financial Issues Taskforce report on considerations on regulatory issues is a non-binding report. Issues identified in the report emerged from the international experience on carbon dioxide geosequestration projects and where existing legislation is currently being applied to cover certain components of carbon dioxide sequestration projects. Carbon Sequestration Leadership Forum members are encouraged to consider the issues identified in the report in the context of their own domestic policies and frameworks.

Domestically – Carbon Dioxide Geosequestration Regulatory Working Group

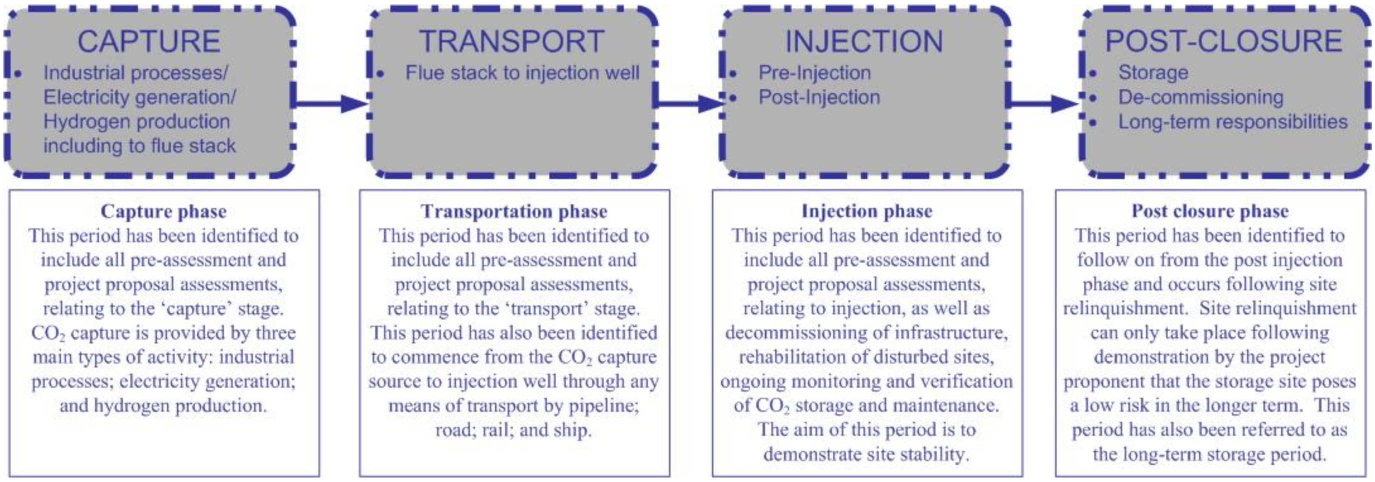
The domestic and international efforts should not be confused. The Australian draft regulatory guiding principles for carbon dioxide geosequestration and the Carbon Sequestration Leadership Forum Taskforce report on considerations for regulatory issues are two distinct documents.

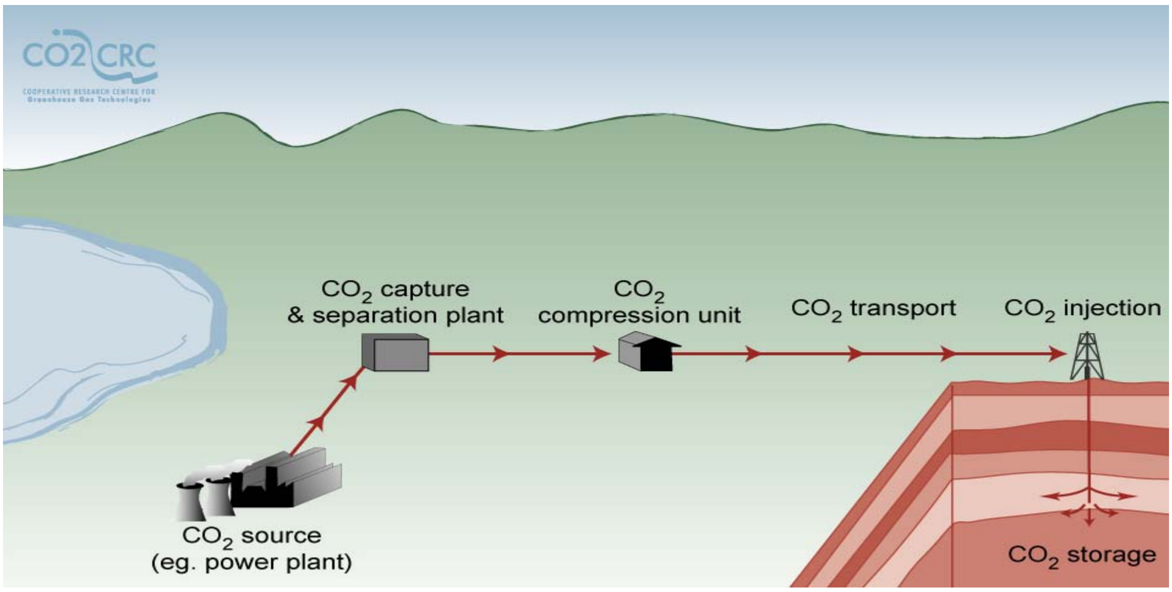
The Australian draft regulatory guiding principles have been drafted specifically with our own local regulatory needs in mind. However, they are consistent with the international principles and our international obligations.

Many aspects of carbon dioxide geosequestration, particularly capture, transport and injection are similar to current pipeline and oil and gas production regulation in Australia. Storage of carbon dioxide is a newer area. However, some of the monitoring technologies required for carbon dioxide storage are already used in the oil and gas industry. For example, seismic is a technology that is already used to assist in identifying oil and gas resources and can be used to monitor the migration of carbon dioxide. Seismic operation for oil and gas activities are regulated in Australia.

A carbon dioxide geosequestration project is structured around a continuum of activities from the emission of carbon dioxide through four broad stages: capture, transport, injection and post-closure. In this document, this continuum is simply referred to as ' carbon dioxide geosequestration' for ease of reference.[1]

Carbon Dioxide Geosequestration Project Life Cycle





Source: Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)

[1] It must be noted that geosequestration is injection and storage in geological formations, whereas ocean sequestration is injection into the ocean at depths of greater than 2000metres. Ocean sequestration is not being considered by Australia.

Carbon Dioxide Geosequestration Risks

Geological storage of carbon dioxide aims to mimic the geological processes involving the trapping and storage of hydrocarbons (often with carbon dioxide). It utilises well proven mature technology from the oil and gas industry for compression, injection, transportation and monitoring of gases and fluids. With appropriate site selection, monitoring and operation of the site, the likelihood of leakage from the subsurface will be extremely low.

The process of capture, transportation and sub-surface injection of gases and fluids are undertaken in Australia and internationally for applications such as gas storage. The operational standards of the existing industries that routinely undertake these activities and the applicable regulatory practices are well established and effective. For example, within the petroleum industry; enhanced oil recovery (which often involves transportation and injection of carbon dioxide) is a proven technology which has been used in the US and Canada for more than thirty years. This experience has led to tools and expertise needed for carbon dioxide transportation and injection to be managed safely.

The environmental impact and associated risks of carbon dioxide geosequestration are dependent on factors such as rock and fluid chemistry, physics of the reservoir, seal formations and the integrity of the encapsulating structures. Potential chemical and physical interactions between the carbon dioxide and the surrounding geology are the subject of ongoing research. However negative environmental impacts of carbon dioxide will not arise unless it migrates beyond the anticipated containment zone. The potential environmental impact associated with migration beyond the containment zone would dependent on factors such as location of emission and concentration of carbon dioxide.

The most common cause of carbon dioxide exposure from geosequestration projects would be well head failure that results in carbon dioxide leakage. In the majority of cases the problem is quickly identified and the well promptly repaired or plugged.

Subsurface lateral migration of fluids through geological formations occurs at the rate of millimetres to centimetres/year, such that during the post-injection phase of an injection project, the likely impact of carbon dioxide on adjoining subsurface regions will also be on geological timescales, i.e. hundreds of thousands to millions of years. The lateral migration rates of both carbon dioxide and the displaced formation fluids will be greater than this during injection[2], and monitoring technologies will need to be deployed to determine whether the behaviour of both the carbon dioxide and the displaced fluids is mirroring that predicted from pre-injection modelling.

Technical issues associated with injection sites can be deliberately targeted in the early phase of a project through exploration, testing, data acquisition and modelling and therefore can produce a highly developed understanding of any complexities and uncertainties.

Other Countries and their Projects

Carbon dioxide geosequestration projects have been operating successfully in other countries since 1996. Norway has been injecting one million tonnes of carbon dioxide per year since September 1996 in the sub surface beneath the North Sea in the Sleipner offshore gas field. Carbon dioxide has been stripped from the produced natural gas and injected into a sand layer. Since injection started, carbon dioxide has been injected without any significant operational problems observed in the capture plant or in the injection well. The Sleipner project is the first commercial application of carbon dioxide storage in deep saline aquifers in the world.

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[2] The rate of migration during the injection phase will be subject to project specific qualities, for example, the rate of injection, the pressure resulting from the injection rate and the characteristics of the reservoir.

The Weyburn project in the US and Canada is the latest opportunity to monitor the sequestration of carbon dioxide in geological formations. In this case, the geological formation is a depleted oil reservoir whereby carbon dioxide is being injected as part of an enhanced oil recovery project in the Weyburn oil field in Southern Saskatchewan in Canada. Enhanced oil recovery is a commercially proven technology. It has been used extensively in the US, where seventy four projects are now operating. Over the 20-year lifetime of the project it is expected that some twenty million tonnes of carbon dioxide will be stored in the Weyburn oil field.

3. THE PROBLEM – NO REGULATORY FRAMEWORK FOR CARBON DIOXIDE GEOSEQUESTRATION

Carbon dioxide geosequestration is a relatively new technology which, as yet, has not been used in Australia. It has the potential to reduce greenhouse gas emissions from stationary energy and other sources. While this relatively new technology is important because fossil fuels are likely to remain the major form of energy for the foreseeable future there are potential health, safety and environmental risks with carbon dioxide geosequestration which will need to be managed by governments to avoid negative consequences to the community.

For example, the environmental risks associated with carbon dioxide and its interaction with the atmosphere, soils, water and the biota are relatively well understood, however, further research and monitoring is required to fully understand the issues that may be associated with long term geological storage. A hazard can arise if carbon dioxide, which is denser than air, is allowed to accumulate in low-lying, confined or poorly ventilated spaces or if there is a gas cloud release occurs if injection fails due to the non-odorous nature of carbon dioxide. However, these risks can be easily managed with adequate monitoring. There is also the slight risk of carbon dioxide migrating out of the storage reservoir and into one or more surrounding geologic formations. This in turn could result in the contamination of freshwater aquifers, and/or interference with the activities at producing oil/gas reservoirs or coal mines.

Environmental issues that will need to be managed include:

- the potential implications of mixed gas streams (i.e. in the event of an unplanned release from either the capture, transport or injection stages of a carbon capture and storage project);
- the long-term implications of carbon dioxide in-situ in geological structures;
- the environmental implications of carbon dioxide migration or escape from containment zones and the risk of these events occurring; and,
- the environmental implications of the storage of non-pure carbon dioxide.

While, carbon dioxide is a naturally-occurring constituent of air which is essential to all life forms, is a non-toxic, inert gas and is generally regarded as safe, at elevated concentrations, carbon dioxide can cause harm to humans. The effects of elevated carbon dioxide levels depend not only on the concentration but also the duration of exposure. The ambient concentration of carbon dioxide in the atmosphere is currently about 370 parts per million (ppm) or less than 0.04 percent. For humans, there are no adverse health effects for carbon dioxide concentrations up to three percent. While some discomfort occurs for concentrations between three and five percent, it is only for concentrations above five percent that there are serious, possibly fatal, consequences. At concentrations above 25 percent to 30 percent, loss of consciousness occurs within several breaths and death quickly thereafter.

The three main concerns associated with carbon dioxide geosequestration in terms of health and safety are:

(1) The transport of carbon dioxide by pipeline presents a potential safety hazard to workers and the general public (negative externality).
(2) The injection of carbon dioxide into a geologic reservoir presents a potential safety hazard to workers (negative externality).
(3) The storage of carbon dioxide bin a geologic reservoir presents a potential safety hazard to the general public (negative externality).

A more detailed analysis of the negative externalities associated with health, safety and the environment for carbon dioxide geosequestration are described at Attachment B.

Another matter of concern for carbon dioxide geosequestration is the lack of a consistent framework has the potential to cause uncertainty for projects. That is, if proponents looking to invest in carbon dioxide geosequestration are faced with unclear and inconsistent requirements and little guidance on how to proceed, they could decide to invest elsewhere.

In this relatively new field, a regulatory framework to assess and manage carbon dioxide geosequestration activities is currently lacking, especially the aspect of storage. A nationally consistent regulatory framework that aims to minimise environmental, health and safety risks and provides methods for dealing with any long-term risks and investor certainty would provide a significant starting point for jurisdictions when considering their own regulatory needs. However, it is important to note that each jurisdiction would decide how to apply that regulatory framework.

It is also important to note that where regulation is recommended in this paper, the ultimate form of the proposed government regulation under the Council of Australian Government Regulatory Impact Statement process has not been decided. Further discussion and research will be required prior to making a decision.

4 OBJECTIVES

The objective of government is to introduce a regulatory framework within which industry can develop an emerging carbon capture and storage technological process. The framework needs to be transparent, predictable and practical providing community confidence and investor certainty. The purpose of the framework will be to improve economic efficiency and certainty in environmental, health and safety management wherever possible. The framework should provide for the development of regulation which will allow consistency in assessment and approval processes for regulators in cross-jurisdictional projects in Australia. The proposed framework does not explicitly increase the economic incentive to undertake geosequestration.

The framework will aim to be:

- in the best interests of the community in the areas of health, safety, environment, economic consequences and government accountabilities;
- based on sound risk management principles; science based and rigorous, yet practical in approach;
- clear and consistent in laying out rights and responsibilities of participants;
- efficient (cost-effective) from participant, government and community viewpoints;
- timely and comprehensive in considering planning and approval requests;
- adaptable and learning-oriented to profit from experience and future developments in technologies, markets and institutional arrangements;

- flexible to allow for future government decisions regarding possible greenhouse policy measures; and
- in a form that maintains Australia's international competitiveness.

The role for Government in the market is to optimise the competition and regulatory framework. There is a role for Government in correcting market failures, including countering socially or environmentally undesirable outcomes. For example, the market may not properly value externalities created by energy efficiency or innovation. But government intervention is justified only where it is well targeted, cost-effective, affordable and efficient, promoting appropriate signals within a credible long-term framework.

5. ANALYSIS

The seven key issues identified by the Regulatory Working Group as being fundamental to the successful implementation of a carbon dioxide geosequestration framework have been analysed. These key issues are:

- Access and property rights
- Long term responsibilities
- Environmental protection
- Authorisation and compliance
- Monitoring and verification
- Transportation
- Financial issues

Each issue will be analysed using three options.

Option 1 – Rely on market – no regulation
Market based methods provide firms and households with incentives to act in a socially preferred way. They can often be more cost-effective than regulations. The market should be relied on if there is the incentive for individuals and groups to act in a certain way which leads to the desired community outcome. Such incentives may include industry survival, market advantage or the threat of more severe regulation.

Option 2 – Self regulation
The option of self regulation involves industry developing and adhering to regulation itself. This should be considered where low risk events present no major public health and safety concerns and environmental or other impacts on the community. Self regulation in the context of this Council of Australian Governments Regulatory Impact Statement is characterised by industry formulating rules and codes of conduct. Sometimes rules or codes of conduct are developed to protect or confer commercial advantage on one group over another, or to exclude new entrants to an industry. On the other hand, standards can sometimes reduce the ability for consumers to choose lower cost and/or lower quality products and services. Self regulation is common amongst the professional and financial sectors.

Option 3 – Government regulation

Government regulation in the context of this Council of Australian Governments Regulatory Impact Statement is characterised by quasi-regulation, which refers to a wide range of rules or arrangements by which governments influence businesses to comply, but which do not form part of legislation. Co-regulation typically refers to the situation where industry develops and administers its own arrangements, but government provides legislative backing to enable the arrangements to be enforced and explicit government regulation refers to primary or subordinate legislation. Explicit regulation should be considered only where the problem is perceived to be high risk, there is a need to provide legal sanctions and consistent application is required. Government regulation could also be a mixture of these different forms.

Each analysis will consider whether the option:

- aims to protect the community's interests, particularly to minimise risks to health, safety and the environment;
- will provide a nationally transparent and consistent approach to carbon dioxide geosequestration – this is important so that jurisdictions can learn from each other given it is a relatively new technology;
- is efficient (cost-effective) from project proponent, government and community viewpoints;
- is flexible to allow for future government decisions and possible greenhouse policy measures.

Each issue will be analysed using the three options i.e. no regulation, self regulation or government regulation and the objectives described above. In addition, the issue of cost recovery is also considered for each of the seven key issues described. When the cost or benefit of one of the seven key issues is not known, further information has been requested.

5.1 ACCESS AND PROPERTY RIGHTS

Externalities arise in the absence of well-defined, exclusive and enforceable property rights. A property right is an entitlement, or bundle of entitlements, defining the owner's right to use a resource and any limitations on its use. For property rights to be effective, the owner must be able to exclude others from the property, to appropriate the benefits from the property, to prevent others from damaging the property, and to enforce the property rights. When such property rights exist the costs and responsibilities associated with an activity are borne and behaviours are modified such that externalities no longer occur.

Resources may be used inefficiently where externalities exist. Therefore, ownership of carbon dioxide at each stage of a carbon dioxide geosequestration project needs to be established in legislation and be transferable, with the rights and responsibilities associated with ownership clearly defined and predictable, taking into consideration the long term risks and management.

In addition, the approval of carbon dioxide geosequestration proposals should take into account the public good aspect of carbon dioxide geosequestration in terms of greenhouse emissions avoided. Existing and future surface and sub-surface rights, as reservoirs and injection sites are likely to be subject to competing claims from other users.

To limit the concentrations of "impurities", such as hydrogen sulphide and nitrous oxide, in the gas the quality of carbon dioxide that can be sequestered will need to be defined to avoid carbon dioxide geosequestration gas being classified as a waste product.

Option 1 – no regulation

Contract, commercial and property law could be used to regulate the ownership and transfer of carbon dioxide. This would mean that prices would be set by market mechanisms and would therefore be consistent with other energy sources. In addition, carbon dioxide geosequestration is an application of a new technology where no precedent exists for contract, commercial and property law, in Australia, which could prove costly and timely if litigation was pursued.

The owner of the land could allocate pore space in accordance with freehold title in some jurisdictions. Landowners could also use veto rights to block site access to those wishing to sequester. Access arrangements would need to be negotiated with the landowner and this may impede carbon dioxide geosequestration if the owner utilised that veto power. Any contractual arrangement for the purchase of a geosequestration site would need to include such risks, which would be negotiated and agreed with the landowner prior to signature.

Market allocation methods such as auction and tenders could be used to allocate storage sites. This method would ensure that the market determines the price. However fears remain that a monopoly power could exist. Lack of competition could prevent third party access to the limited number of storage sites, monopolies could result in the society sub-optimal outcomes of decreased storage opportunities and prices being set at inefficiently high levels. The existence of substitute technologies could decrease the likelihood of monopolies developing.

Option 2 – self regulation

A code of conduct could be established to govern access and property rights for instance in negotiating access to land with landowners. This could include industry standards such as those that are already utilised in similar areas such as petroleum and mining, for instance native title. Where matters of access are uncertain common law (torts and contract) and existing legislation (eg. commercial and environmental) could be required for dispute resolution. However, there is likely to be uncertainty for both project proponents and landowners in relying on common law, because carbon dioxide geosequestration is a relatively new technology and as for the option of no regulation, precedent does not exist which could prove costly and timely.

Option 3 – government regulation

To provide certainty, the point of change in ownership/responsibility for the carbon dioxide needs to be clarified to allow storage and movement of carbon dioxide. In addition, ownership of storage sites including government or private landowners, veto power and compensation need to be clearly defined. The nature and scale of future carbon dioxide geosequestration projects will be influenced by technical practicalities, costs and the arrangements. While these factors cannot be anticipated, suitable carbon dioxide reservoirs may be scarce and contested, and there is a need to provide for the simultaneous and (where possible) subsequent use of reservoirs by multiple injectors.

Government regulation needs to ensure that a framework provides for issues including, permits that cover exploration and utilisation of storage sites, duty of care considerations, compensation, and cost recovery/pricing structure for storage and access. A statutory definition of storage site to store carbon dioxide is needed to ensure that only suitable storage sites, in terms of geological characteristics, are used to store carbon dioxide.

Different State and Commonwealth technical advisory bodies may exist to provide suitability assessment and project approvals for carbon dioxide geosequestration. These jurisdictions may have different approaches leading to a lack of national consistency. Developing a framework for carbon dioxide geosequestration based on existing frameworks, accommodating the best features of each option and ensuring consistency with existing regimes would avoid duplication. New regulation could be introduced where there are gaps in existing regulation or where existing regulation is inapplicable. Regulation could be in the form of new or existing arrangements/ regimes to resolve jurisdictional issues between State and Commonwealth to deal with offshore and onshore ownership.

Recommendation

Using existing contract, commercial and property law would not impose additional costs on interested parties unless there are conflicts. Explicit government regulation is the preferred option as it would be transparent, provide certainty and specifically regulate carbon dioxide geosequestration activities with the aim to minimise associated risks to health, safety and the environment. Government regulation would best protect the community’s interests by including the best features of existing frameworks and introducing new regulation where there are gaps, codes of conduct would be enforceable, it would be nationally clear and consistent and it would be flexible enough to allow for any future changes.

5.2 LONG TERM RESPONSIBILITY

Potential sources of liability for carbon dioxide geosequestration include public health impacts and environmental and ecosystem damage. Carbon dioxide is generally considered a safe, non-toxic gas at low concentrations, and does not directly affect human health. However, the gas is denser than air and may re-accumulate in low-lying, confined or poorly ventilated spaces. The choice of appropriate sites is the best way to minimise any adverse effects related to carbon dioxide geosequestration storage, the possible increase in mitigation and management of risk and levels of fugitive emissions from capture, transport and injection facilities.

The issue of cost recovery may be a consideration in relation to long term responsibility for geosequestration sites. It has been proposed by the Regulatory Working Group that government accept long term responsibility for site monitoring and maintenance following demonstration by the proponent that a minimum set of criteria is met. Whatever the service provided, it may be appropriate to seek cost recovery from industry. If cost recovery is not undertaken, the costs to government are effectively borne by the community (taxpayers). However, where cost recovery is undertaken, the additional costs to those utilising government services may be passed on the final consumers of the product, (in this case energy), otherwise make carbon dioxide geosequestration an unfeasible technology.

The issue of legal liability is typically assessed in the terms of negligence and strict liability. Negligence is the failure of persons or corporations to follow reasonable care. That is, they would find a professional negligent if they did not exercise the skill and knowledge normally possessed by members of the same profession. Strict liability is an effort to internalise costs. That is, a person or corporation is held liable for the harm that his, her or corporate activity caused regardless of whether reasonable care was used.

Post closure liabilities in the post closure period will need to be clear. Analogies from the decommissioning of petroleum and mine sites operations, long term management of hazardous waste disposal sites and contaminated site remediation provide models to assist in understanding liabilities in the post closure phase. Using these models, the project proponents retain some liability over the site in the post closure period. However, it is likely that government will assume some liability for the project particularly in the longer-term. The scope, nature and allocation of liability following site closure needs to be resolved by deciding whether existing common law is adequate or whether amendments to existing regulation or new regulation is required to provide greater clarity.

Clearly defining long-term responsibilities and liabilities associated with carbon dioxide geosequestration projects is a priority. The lack of a clear framework with which to consider long term responsibilities and liabilities could leave government and future generations exposed in terms of environment, health and safety risk and financial cost. How long-term responsibilities are managed will be a key factor in gaining community acceptance of carbon dioxide geosequestration projects.

Option 1 – no regulation
Currently, common law would find a person negligent if they do not exercise reasonable care. While there is case law relating to environmental issues carbon dioxide geosequestration is a new technology and no precedent exists for this particular matter. Relying on common law could prove costly and timely for industry if litigation was pursued. This would create uncertainty for the community, government and industry.

Option 2 – self regulation
Most industry standards and codes relate principally to operational periods for up to several decades, perhaps as many as one hundred years. In contrast, carbon dioxide storage is required for thousands of years. New standards would need to be developed by industry, which would be costly for businesses but beneficial for government and the community. However, without some form of incentive, businesses are likely to take community concerns into account and therefore, industry may not voluntarily develop appropriate standards or codes for carbon dioxide geosequestration.

It could be argued that industry should be responsible for carbon dioxide geosequestration projects following closure in the long term. This will be costly for the industry to perform this function and could result in industry choosing between economic and social responsibilities. Common law would need to be relied upon similar to the option of no regulation which would cause uncertainty for the community, industry and government.

There is also the question of who pays if the proponent is declared bankrupt or cease to exist. In the event of a company bankruptcy, it is not clear how residual responsibility will be managed.

Option 3 – government regulation
Appropriate regulation and management from the planning and site selection can decrease long-term risks to public health and the environment. Any regulatory framework will need to place human health and safety at the forefront to gain public acceptance of carbon dioxide geosequestration.

Long-term responsibility for the decommissioning and rehabilitation of onshore carbon dioxide sequestration facilities will be largely a State based matter. In contrast, the offshore decommissioning and rehabilitation of facilities is more complex due to international guidelines and treaties, and due to the guidelines and treaties being set up prior to carbon dioxide geosequestration technology. Accordingly, the offshore decommissioning and rehabilitation of facilities will be, to some extent, dependent on the interpretation of these international treaties. This work is being progressed through the International Energy Agency in conjunction with Carbon Sequestration Leadership Forum members.

A multitude of State, Territory and Commonwealth regulations potentially apply to carbon dioxide geosequestration activities, both pre and post closure. A common and consistent government regulated framework that considers long term responsibilities and liabilities associated with carbon dioxide geosequestration activities will be required to ensure governments and future generations are not exposed to health and environmental and financial risks and financial burden.

Decommissioning and rehabilitation regulations that are currently in place for the mining and petroleum industries could be adopted for carbon dioxide geosequestration. In particular, the existing petroleum regulation at both a State and Commonwealth level provides guidelines for the decommissioning of facilities that are similar in nature to those for carbon dioxide geosequestration, which could be utilised. This is particularly relevant for high pressure pipelines and wells.

Petroleum and mine site operations, long-term management of hazardous waste disposal sites and contaminated sites remediation provide models to assist in understanding liabilities in the post closure phase. If these models are used, the project proponents will retain some liability over the site in the post closure period.

Governments should not permit site closure until they are satisfied to a high degree of certainty that future land use objectives are met, residual risks of leakage and liability are at an acceptably low level, and ongoing costs associated with the site are acceptably low or can be otherwise managed. The burden on government would include the initial assessing of site options and ensuring that the closure of sites is adequately addressed.

The cost of the developing post-closure management phase for the transfer of the environmental and health risk will fall to proponents. However, some benefits will accrue to the general public such as the reduction in possible liability on consumers by ensuring all prerequisite standards and conditions are met for transfer of ownership from private to public or between commercial parties.

Recommendation

The management of long term responsibilities and liabilities will be a key factor in gaining community acceptance of carbon dioxide geosequestration projects. The long-term risk of carbon dioxide geosequestration to health, safety and environment can be minimised by regulation of these aspects where possible at the commencement of the project. Therefore, the option of government regulation, which includes a combination of explicit regulation, co-regulation and quasi-regulation, would best achieve the desired objectives. That is, the community's interests would be best protected by appropriate regulation, modelling existing successful long-term management regulation, being in place from the outset of carbon dioxide geosequestration activities therefore minimising any possible risk and financial burden. Government regulation that is common and consistent rather than unrealistically relying on private owner/operators or industry to remain responsible for the site in perpetuity would ensure that the community's interests are protected.

It is still to be decided whether liability for carbon dioxide geosequestration will be treated in the same way as petroleum and mining activities which have imposed relatively low costs on operators due to a lower risk. Further work is proposed on the long-term risks and liability.

Question: Is information available on the costs and benefits of long-term liability for carbon dioxide geosequestration projects?

5.3 ENVIRONMENTAL ISSUES

The environmental issues and risks associated with carbon dioxide and its interaction with the atmosphere, soils, water and the biota are relatively well understood. However, further research and monitoring is required to fully understand the issues that may be associated with long-term geological storage. Existing environmental regulation at both Commonwealth and State levels could be applied to carbon dioxide geosequestration projects with minor amendments.

Commonwealth environmental regulation that may apply to carbon dioxide geosequestration includes the *Environmental Protection and Biodiversity Conservation Act 1999* and the Petroleum (Submerged Lands) (Management of Environment) Regulations 1999. Additionally, State and Territory legislation covering environmental aspects of planning and approval processes for industrial projects may also apply.

The primary issue for carbon dioxide geosequestration projects however, from an environmental protection perspective is likely to be proving the science, public perception and confidence. Therefore, all existing Commonwealth, State and Territory environmental legislation may require amendments specifically to allow for carbon dioxide gas.

Option 1 – no regulation

Relying on the market and not regulating carbon dioxide geosequestration would not address the community concerns of environment, health and safety. There would be no framework to guide the industry on what is expected of it, particularly in terms of what it should take into account in engaging the community and arriving at acceptable environmental performance standards. Industry would be responsible for developing its own processes for establishing appropriate operating standards. In the case of an environmental event where there was no regulation and the proponent was unable to finance the costs, government outlays would be substantial as they would be left to rehabilitate the site.

Question: Is it possible to quantify the costs of rehabilitation for a carbon dioxide geosequestration project?

Equally, the community and government would have no framework for being assured that industry proposals are subject to appropriate environmental scrutiny. Achieving acceptable standards and compliance would be through community reaction to operations, and this is likely to lead to uncertainty for all parties and a high potential for disputes between the industry and community groups.

Relying on the market would not provide any incentive for specific scientific research to be carried out to prove up the science required for greater confidence in the technology.

In the case of regulations ensuring certain levels of protection in relation to geosequestration activities, it is arguable that the broader community benefits through greater safety and environmental assurances. However, the only reason consumers require this additional protection is because companies undertake geosequestration activities. Externalities flowing from geosequestration activities, which include negative perceptions, make the community worse off, and regulations which seek to protect consumers against this return them to the status quo. Costs created by an unregulated environment are generated by the individual companies undertaking geosequestration activities therefore, the seeking of cost recovery may be appropriate in this instance.

Option 2 – self regulation

Self regulation would require industry to set the environmental performance standards it considered acceptable. Many of the potential natural, cultural, social, economic and environmental effects of carbon dioxide geosequestration operations would occur external to the operations. There would be significant community concern that these externalities would not be adequately accounted for by the industry in setting the performance standards.

Similarly to the option of no regulation there would be no framework to guide the industry on what is expected of it, particularly in terms of what it should take into account in engaging the community and arriving at acceptable environmental performance standards.

It could be argued that lack of regulation does not provide adequate oversight of industry activities, thus abrogating the government's responsibility to protect the environment on behalf of the community. Equally, industry could argue that there is inherent uncertainty and potential for costly delays and interruption of operations through the actions of groups opposed to the industry or particular developments.

Carbon dioxide geosequestration project proponents would be responsible to the community as a whole and not just to the parties involved in a contractual agreement. Therefore, environmental issues would need to be included in contracts and codes of conduct. However, if the dispute resolution mechanism set out in the contract or code of conduct is insufficient, common law and existing environmental legislation would be relied on to provide advice, compensation and penalty options. If situations arose where common law and legislation must be referred to, this could lead to increased costs in the form of legal fees and possible court costs, particularly because carbon dioxide geosequestration is a new technology and no precedent exists which could prove costly and timely if litigation was pursued. This would create uncertainty for the community, government and industry.

Option 3 – government regulation
As described in the section on long term responsibility, decommissioning and closure of petroleum and mine sites and long term management of hazardous and contaminated waste could provide a model for carbon dioxide geosequestration.

Industry would be required to comply with a regulatory regime, regulators would be required to ensure compliance and community interest groups would be involved to a greater or lesser extent in consultation during the approvals process and at times in assessing performance or impact of particular operations. Costs for government would include ensuring industry's compliance with the regulations, administration and public reporting on inventory and environmental aspects however, there would be reductions in government outlays through preventable health, safety and environmental damage.

Benefits for the general public of government regulation include decreased in carbon dioxide emissions, possible contribution to sustainable environment for future generations, potential improved health and safety, and increased potential for consumer/public satisfaction as risks are reduced.

Recommendation
In terms of the community's interests, having no regulation would not adequately address the protection of the environment s and the potential externalities. The options of no regulation and self regulation would both result in the industry being left to set the environmental performance standards it considered acceptable. Existing regulation could be generally applied to carbon dioxide geosequestration activities or could be slightly amended at minimal cost to specifically apply to carbon dioxide geosequestration. This would therefore be cost effective, clear and consistent as well as protecting the community's interests. Therefore, the option of explicit government regulation would best achieve the desired objectives.

See Attachment B for a more detailed description of the environmental risks associated with carbon dioxide geosequestration. However, further information is required on monitoring and verification. Please submit any further information available.

5.4 AUTHORISATION AND COMPLIANCE

Authorisation and compliance is important not only for financial reasons (assessment of royalties, possible government dues, determination of surface property and mineral rights) but also for practical reasons such as record keeping to avoid earlier carbon dioxide storage sites as well as data on wellbore features. Authorisation and compliance is also important to ensure the rights and responsibilities of commercial parties and interests of communities are addressed. Activities for authorising and ensuring compliance of carbon dioxide geosequestration operations are closely related to those processes associated with already established commercial industries, such as mining and petroleum.

Option 1 – no regulation
Common law and statute law could be used to enforce any authorisation and compliance issues that arise. This may not be publicly acceptable because authorisation and compliance is a major part of minimising risk, especially potential environmental risks. If situations arise where common law and legislation must be referred to, this could lead to increased costs in the form of legal fees and possible court costs particularly because carbon dioxide geosequestration is a new technology and no case law currently exists. This would create uncertainty for the community,

government and industry.

For business, a benefit would be no increase in costs such as compliance and monitoring costs that would be associated with having to alter production and time spent training staff. For government the potential costs would be to the environment, health and safety of the community. In addition, lack of authorisation and compliance for carbon dioxide geosequestration activities could lead to environmental events that would negatively impact on our international relations, particularly if it is the result of being inconsistent with international guidelines and treaties.

Option 2 – self regulation
A code of conduct could be established and utilised for monitoring, authorisation and compliance with environmental, health and safety standards. Public accessibility to this information would ensure transparency and aid in consistency and compliance. However, a code of conduct would lack enforceability except through contract law or if used in conjunction with regulation.

The lack of incentive for business to set standards as high as government might set may be beneficial as the cost of implementation and compliance may be less than if government regulation was introduced. If a code of conduct or industry agreement was introduced the compliance costs to business would increase.

Option 3 – government regulation
If carbon dioxide geosequestration regulations for authorisation and compliance mechanisms were introduced to address potential environment, health and safety risks, these regulations would need to address the rights and responsibilities of commercial parties while seeking to protect the community's interests.

Activities for authorising and ensuring compliance of carbon dioxide geosequestration operations are closely related to those processes associated with established commercial industries which form part of the chain of activities associated with carbon dioxide geosequestration.

Regulation equivalent to existing environmental regulations for mineral processing, chemical manufacturing or electricity generation plants could be applied to carbon dioxide geosequestration. Similarly, regulation equivalent to existing occupational health and safety regulations for chemical facilities could be applied to carbon dioxide geosequestration.
New regulation in the form of modified existing legislation or the introduction of new legislation may need to be adopted to ensure geological carbon dioxide storage sites are managed safely. Specifically, for each potential geological carbon dioxide storage site, it needs to be demonstrated that the leakages will be reduced to minimum levels and the dispersion sufficient enough to prevent the accumulation of hazardous carbon dioxide concentrations.

The costs to business include costs such as compliance with changes in applicable licensing or environmental requirements and compliance with changes in regulations governing operating procedures, which would adjust the costs of regulation on business. However, Government regulation would also benefit business by increasing certainty in regulatory compliance costs.

Recommendation
As authorisation and compliance is a major part of minimising risks, having no specific regulation or relying on a code of conduct without government backing may not be publicly acceptable because there would be no enforceability except through general common law and statute law. A nationally agreed framework for regulation on the other hand, which is common and consistent, could allow flexibility when necessary, could specifically address issues regarding the minimisation of risks, and could be cost effective because existing legislation

could be slightly modified to apply to carbon dioxide geosequestration activities therefore minimising costs. Therefore, the option of explicit government regulation would best achieve the desired objectives for authorisation and compliance.

Question: The risks to health and safety are described in more detail in Attachment B. However, further information is required on storage of carbon dioxide over long periods of time. Is there any information on the costs associated with the authorisation and compliance of long-term storage?

5.5 MONITORING AND VERIFICATION

After a carbon dioxide storage reservoir has been sealed, the time during which the reservoir is over pressured would appear to represent the greatest potential for short-term significant leakage. Current modelling calculations suggest that this time period is relatively short a few decades. Thus, effective sealing at abandonment would decrease the chances of leakage during this transient period. Drilling through the storage formation for other purposes also poses risks. Monitoring and verification of wellbore leakage in the decades following the end of carbon dioxide geosequestration injection is likely to be detected and therefore, can be remediated.

Ideally monitoring should be carried out pre injection, during injection and post injection. Monitoring sites should be varied, including several horizons, at the surface, in the shallow subsurface, in the deep surface, and in the injection zone. In addition, monitoring in and around the well bores should be carried out, which overlaps with the previous horizons.

Monitoring and verification of carbon dioxide geosequestration projects needs to be able to deliver high quality information that can be used to effectively and responsibly manage health, safety, environmental and economic risks; information on the volume and location of greenhouse gas emissions that have been abated and are stored underground which are accurate enough to meet inventory reporting and commercial requirements; and to engender public confidence.

Option 1 – no regulation
Commercial drivers for monitoring and verification are profit focused and therefore do not always account for the interests of the community, orderly market development, legal and/or statutory rights of commercial stakeholders and accurate accounting for emissions to meet government reporting obligations and policy needs.

This may benefit the proponent, as there would be no increase in costs such as compliance and monitoring costs associated with having to alter production and time spent training staff. On the other hand the community and government would incur health, safety and environmental costs. However, some companies may wish to do their own monitoring and verification.

Option 2 – self regulation
A code of conduct could be established but this option may not be sufficient because it may not meet the needs of the community. For example, possible increases in the mitigation and management of risk and the timeframe required for ongoing monitoring and verification for industry of levels of fugitive emissions from capture, transport and injection facilities would increase costs to industry. While industry standards could be utilised, currently industry standards are focused on short term rather than the longer-term.

Option 3 – government regulation
The main justifications provided for conducting monitoring once a project is complete are confirmation that there is no leakage, public confidence and accounting for greenhouse emissions. A regulatory framework should be able to deliver mechanisms for monitoring and verification to:

- establish data on the surface and subsurface environment;
- monitor the project environment to manage and mitigate health, safety and environment risks;

- ensure certain standards for health, safety and environment and subsurface behaviour of geosequestration gas are met before responsibility for the project is transferred from private to public interests; and
- develop and manage a monitoring and verification plan to cover the post-closure period after responsibility for the project has been transferred to public hands including outlining how this ongoing monitoring will be funded.

Monitoring and verification is carried out in relation to storage of other materials such as underground gas storage. Projects could be monitored under existing frameworks including, inter alia, for pipelines, petroleum, mining, or waste disposal with minor legislative amendments. A framework specifically for carbon dioxide geosequestration could be developed.

While existing regulation could enable carbon dioxide geosequestration projects to be managed effectively in the short term, carbon dioxide geosequestration is a different process from extraction of hydrocarbons, and may involve different monitoring and verification requirements that may not fit easily within current legislative frameworks. For example, new monitoring and verification standards and guidelines in management plans will need to be developed for carbon dioxide geosequestration before the site can be decommissioned. A new regulatory framework for monitoring and management of carbon dioxide in-situ over very long periods of time would also need to be developed. After the reservoir has been sealed, monitoring should continue as long as government considers it beneficial.

The costs to government would be the monitoring and administration of costs such as the regular review of plans and review of standards and actions. For example, five yearly ongoing reviews mainly by government plus post-closure for a specified period – long term, but this would be cost recovered. While the benefits would include: consistent reporting standards; the assurance that carbon dioxide geosequestration technologies meet national and international standards for accounting; reporting national carbon dioxide inventories across all jurisdictions allowing for a single Australian report to be produced meeting international standards; and an Australia wide mechanism which would cover the costs of long-term monitoring of decommissioned sites.

The costs to business would include audits and reviews of monitoring and verification. While benefits to business would include the development of strategic and project specific monitoring and verification strategies, and government regulation would ensure unambiguous allocation of responsibility for monitoring and reporting during long-term storage of carbon dioxide.

Question: Is there information that quantifies the costs and benefits of monitoring and verification over the long-term?

Recommendation

Relying on the market or on an industry code of conduct would be unsatisfactory because these mechanisms may be more profit focused rather than properly accounting for the interests of the community. These alternative options would probably also lack a nationally common and consistent approach. Alternatively, government regulation would specifically aim to protect the community’s interests by minimising any possible risk and could be nationally consistent. Therefore, the option of government regulation which includes a combination of explicit regulation, co-regulation and quasi-regulation would best achieve the desired objectives.

5.6 TRANSPORTATION

The key differences between transporting natural gas and supercritical[3] carbon dioxide by pipeline from a safety/environmental perspective are:

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[3] A supercritical fluid is any substance above its critical temperature and critical pressure. In the supercritical area there is only one state-of-the-fluid and it possesses both gas- and liquid-like properties. This is not new technology. The phenomena of enhanced solubilities in supercritical fluids has been known since the late 1800s. For decades it has been used in food processing industries to extract compounds such as caffeine and hop oil.

- when carbon dioxide mixes with water it becomes highly corrosive;
- carbon dioxide is heavier than air; carbon dioxide is odourless; and
- carbon dioxide is not flammable.

The risk associated with carbon dioxide transportation in terms of environment, health and safety are:

- the transport of carbon dioxide by pipeline presents a potential safety hazard to workers and the general public (but less that natural gas); and
- injection of carbon dioxide would have to be sufficiently regulated and monitored to manage the risk.

Option 1 – no regulation
There are currently no Australian industry standards governing carbon dioxide geosequestration. This could result in unsafe practices. Developing new standards would be costly for companies especially if they contract an outside organisation to develop the standards.

Question: What would be the magnitude of the costs of developing new standards or codes for companies?

Option 2 – self regulation
Industry standards or a code of conduct could be used. However, this may be a lower threshold than what the government and community would consider adequate. If industry is able to be made liable for damage caused, they would have an interest in developing a code of conduct which provides adequate environmental, safety and health protection.

As described above there is currently no Australian industry standard for carbon dioxide sequestration. Developing such standards would be costly for industry, and these costs would be passed onto consumers.

Question: What would be the magnitude of the costs of developing new standards or codes for companies?

Option 3 – government regulation
Environmental standards currently apply to the route selection, construction and operation of pipelines and in most jurisdictions relevant planning approval or environmental impact assessments are required. Additional regulation relating specifically to carbon dioxide pipelines may not be necessary. However, some amendments to existing pipeline legislation may be needed prior to new pipeline approvals.

All jurisdictions have relevant regulations governing major hydrocarbon pipelines. In some jurisdictions this is contained in State/Commonwealth Pipeline Acts while in others it is contained in Petroleum Acts. Any new regulation should allow access to private and public property for the purpose of transportation of carbon dioxide and construction of carbon dioxide pipelines.

Recommendation
Relying on the market is inappropriate because there are no industry standards that could govern carbon dioxide transportation. Self regulation in the form of a code of conduct would also be inappropriate because it may be perceived to have a lower threshold than what is publicly acceptable. Government regulation on the other hand, already exists in relation to activities using similar techniques as carbon dioxide geosequestration. While existing legislation exists for pipelines there are gaps in the existing legislation. Utilising this existing regulation should be cost effective as minimal new regulation would be required. The community’s interests will also

be protected as this existing regulation takes environmental, heath and safety issues into account.

5.7 FINANCIAL ISSUES

Without Government intervention, companies would be required to accept long-term responsibility for site monitoring and maintenance. If businesses were unable to acquire insurance for this activity, companies undertaking geosequestration activities would be required to bear an unacceptably high level of financial risk. Businesses would be uncertain of all the costs associated with geosequestration, and would find it more difficult to make educated decisions as to whether geosequestration was a profitable option in their particular circumstance. This additional risk and uncertainty would result in geosequestration activities being taken up by industry at a lower rate than would otherwise have been the case. This would be an inefficient outcome, brought about by the existence of a market failure.

In this particular circumstance, the product not being supplied is insurance, and the reason it is not being supplied is the uncertainty about the magnitude and likelihood of potential risks associated with geosequestration activities. Where an incomplete market exists, government may have a role to play in providing the product in order to achieve a socially desirable outcome. There may be a need for government to intervene in relation to long term site responsibility, as failure to act will lead to inefficient market outcomes. However, there are a number of alternatives available; government may choose to provide any or all of the following services:

- Accept responsibility for sites in long term;
- Provide insurance to companies in the short term; or
- Provide insurance to companies in the long term (if the Government decides not to accept direct responsibility for site monitoring and maintenance).

Government provision of insurance would allow companies to undertake their own long term site maintenance with lower level of risk. However, there is a danger of a moral hazard situation where the industry has no/reduced incentive to maintain sites to a high level. Once the market has a greater understanding of the likelihood and types of risk associated with geosequestration, it is likely that private providers would be willing to provide an insurance service, at which point government support would no longer be required.

In relation to the issue of cost recovery, government agencies take the view that they should be able to implement full cost recovery, and industry takes the view that consideration should be given to public benefit of carbon dioxide emissions avoided and that therefore full cost recovery may not be appropriate in all cases.

One issue needing consideration in the drafting of future fiscal and regulatory measures is the distinction between normal commercial maintenance conducted as good commercial practice and any “special social” requirements. On competitiveness regulation, there appears to be no clear reason why normal competition policy principles (for example third party common access and common carriage) should not apply. At this stage no special fiscal issues are apparent in relation to competition policy and transportation of carbon dioxide.

Project viability (and hence financing) will be significantly impacted upon by:

- taxation treatment;
- overall regulatory costs; and
- the treatment of liability/ benefits (and associated insurance issues).

Resolving these issues expeditiously is necessary to give scenario analysts, economic modellers, project developers and finance greater certainty.

Option 1 – no regulation

Final determination of the cost of insurance is difficult; however there is no reason why normal insurance processes should not apply to carbon dioxide geosequestration technologies, transportation and for operation of above ground storage related equipment. However, insurance companies may refuse to insure projects involving storage of carbon dioxide due to the unknown associated risks.

Question: Would companies insure projects? If so, what would be the magnitude of these costs?

Option 2 – self regulation

Self regulation would not preclude industry from insuring against unforeseeable events. A company would need to prove they are managing the risks satisfactorily to qualify for insurance, and this may protect against using 'shelf companies'. However, as above insurance companies may refuse to insure projects involved in storage of carbon dioxide due to the unknown associated risks.

Question: Would companies insure projects? If so, what would be the magnitude of these costs?

Option 3 – government regulation

Regulatory processes should be least cost, should not undermine the international competitiveness of Australian industry, and undue fiscal burden should not be imposed on any jurisdiction or industry as a result of regulatory processes or outcomes.
It may be appropriate that company taxation treatment of capital expenditure be treated in accordance with existing taxation policies that is they are deductible via depreciation arrangements. Equally, for company tax, it may be appropriate that there is no differential treatment of operating costs of commercial corporations for carbon dioxide geosequestration.

There are fundamental differences between how petroleum and some mining royalties are calculated. For example in Western Australia there are three royalty systems that need to be considered for petroleum projects. In the case of mining, it is probably only in relation to deep coal seam gas recovery in Victoria that an issue may arise. In most other cases, since royalty is ad valorem based, the issue of deductibility of capture and storage costs does not apply. Therefore it is possible that in some circumstances costs of storage will be treated in a different manner.

In relation to the fiscal impact on State government instrumentalities and corporations prima facie it would appear that governments will need to consider how issues such as performance bonds and insurance needs are addressed by state instrumentalities for: company tax may not be a relevant issue; and royalty and the Petroleum Resource Rent Tax issues may not arise for a Crown entity. Given that in the longer term it is almost inevitable that governments will be taking legal liability for stored gases, there may be fiscal implications of such a change in responsibility that need to be considered by the relevant jurisdictions.

Recommendation

It may be appropriate that proponents self insure or go to markets as they would do for other similar scale activities. Final determination of the cost of insurance is difficult to assess due to limited demonstrations of the potential for long-term risks. It will depend on consideration of a broad range of issues. For example, issues of long-term ownership, unknown associated risks and public indemnity. Government regulation to clarify ownership is recommended in a form that is least cost while meeting the necessary hurdles of managing risks.

If information is available on the costs and benefits of the cost of insurance and the fiscal implications of a change in responsibility for carbon dioxide geosequestration projects in differing jurisdictions and on and offshore, please forward in submissions.

6. COMPARATIVE ASSESSMENT – FINAL RECOMMENDATION

Option 1 is not supported because it cannot be guaranteed that industry would ensure that risks are reduced to as low as possible. In addition, there is an abundant supply of fossil fuels particularly coal and gas that is expected to last for centuries. Without the certainty of regulation, it may not be a priority to use carbon dioxide geosequestration technologies for greenhouse gas mitigation due to their higher cost. However, the decision to utilise geosequestration technology should remain a commercial decision.

The issues surrounding health, safety and environment considerations may not be adequately addressed and sanctions may not be put in place if left to the market, particularly over the longer term. This would detract from the best environmental, health and safety outcomes and subsequently community understanding and awareness. It may also leave the community with an unfunded liability. .

Option 2 of self regulation is not a desirable option because there may be risks associated with carbon dioxide geosequestration if not managed and regulated properly. Although the industry may self regulate in a way that minimises the impact on the environment and third parties, it may not always act in the best interests of the community.
It is unlikely that self regulation would provide a framework capable of providing assurance to the community that the industry would operate in a manner that achieves community acceptable outcomes involving minimal risks to health, safety and the environment. Therefore, self regulation could also make it more difficult for project proponents to gain community acceptance.

Self regulation does have the benefits of reduced administrative and compliance costs, however, there can be no guarantee that all industry members would agree to self regulation especially if it is in the form of an agreement or arrangement such as an industry code of conduct. Another benefit to business of self-regulation is the freedom to choose the most appropriate, cost-effective technology/process, eventuating in least-cost approach.

Option 3 is the recommended option because, as specifically analysed above, it protects the community's interests, particularly minimises risks to health, safety and the environment; provides a nationally consistent approach to carbon dioxide geosequestration; may be cost-effective from project proponent, government and community viewpoints; and is flexible to allow for future government decisions and possible greenhouse policy measures.

The Australian economy is dependent on the continuing availability of competitively priced electricity. The bulk of base load electricity in the future is expected to be generated from coal and gas but it will need to be generated in an environmentally sustainable manner. Additionally, energy investments are generally long-term. By implementing government regulation, investors will be able to make decisions with full knowledge of what regulatory hurdles they will need to meet to get approval from government for a project. The community can also be assured that their interests are being protected.

Future projects may be cross jurisdictional. Stand alone State and Territory regulation will not cover all regions of Australia. Similarly, by virtue of the Constitution, the Commonwealth only has the power to regulate in 40 specific areas. A combination of Commonwealth, State and Territory regulation that draws on both new and existing regulation could be a possible form that a regulatory framework could take.

If existing legislation is to be relied upon decisions will need to be made how such legislation would manage carbon dioxide geosequestration activities. To avoid time and costs involved in duplication, existing regulation could be adapted and amended to address carbon dioxide geosequestration activities. New laws and regulations could be introduced where there are gaps in existing regimes or where the existing regime is not readily applicable to carbon dioxide geosequestration.

This regulation could be managed by the relevant jurisdiction and where appropriate in consultation with other affected jurisdictions to ensure national consistency. The analysis supports the use of existing legislation wherever possible to avoid additional regulatory burden. Most aspects of carbon dioxide geosequestration are similar to activities which have already been undertaken in the oil and gas industries for decades. Existing oil and gas regulations available in the Commonwealth, States and Territories provide an adequate starting point for developing a framework. In view of the long-term storage requirement for carbon dioxide geosequestration however, specific regulations may need to be developed.

It is therefore recommended that government regulation (a combination of Commonwealth, State and Territory legislation and of new and existing regulation) be used to manage the capture, transport, storage and post-closure phases of carbon dioxide geosequestration. As described in the recommendations under each issue, in the context of this Council of Australian Government Regulatory Impact Statement, government regulation is not limited to regulation. In some areas, it may be appropriate to consider co-regulation as a more efficient and cost effective alternative.

7. CONSULTATION

Ongoing consultation is occurring with relevant stakeholders including Commonwealth agencies, State Governments, industry and research organisations, relevant international agencies and environmental non government organisations. This consultation takes place within the following groups:

- Commonwealth Inter-departmental Committee – established in February 2003 and consists of eleven Commonwealth government agencies.
- Carbon Dioxide Geosequestration Regulatory Reference Group – established in September 2003 and consists of twenty two member agencies including State and Commonwealth government agencies and industry representatives.
- Carbon Sequestration Leadership Forum – established in June 2003 and consists of sixteen member countries.
- Australian Carbon Sequestration Leadership Forum Reference Group – established in February 2003 and consists of twenty nine member agencies including State and Commonwealth government agencies and industry representatives.

Through these various groups and associated consultation with government agencies and industry, consensus has been reached on the proposed draft principles that is intended to form the basis of government regulation in each jurisdiction. Additional consultation subject to public consultation with non government organisations and the community is currently being progressed.

Targeted consultation meetings with relevant non-government organisations were conducted with the following groups:

- Climate Action Network Australia

- Australian Conservation Foundation
- Western Australian Conservation Council
- Environment Victoria
- Greens Party Western Australia

While only a small number of relevant non-government organisations have been consulted in the first stage in establishing a regulatory framework, the five organisations above are key non-government organisations on carbon dioxide geosequestration. Climate Action Network Australia is the peak non-government organisations body with responsibility for climate change issues. The Western Australia Conservation Council is an umbrella organisation of nearly seventy affiliated conservation groups from throughout Western Australia, and Environment Victoria is the State's peak non-government environment organisation.

These sessions included:

- Brief explanation of carbon dioxide geosequestration technologies;
- Overview of Ministerial Council on Minerals and Petroleum Resources Regulatory Working Group work to date
- Explanation of proposed regulatory principles;
- Next steps, including continued consultation when implementing regulation/legislation; Comments and questions.

The main comments and concerns raised at the non-government organisations consultations are as follows:

- Generally, non-government organisations are not totally opposed to carbon dioxide geosequestration, but have issues with the use of sequestration versus renewables.
- Carbon dioxide geosequestration is not being discussed enough in the community. The government representatives explained the information/consultation sessions that have been proposed and will take place in the near future.
- Cost of carbon dioxide geosequestration as compared to sources of renewable energy and how the draft principles fit with Australia’s international obligations. Both of these issues are currently being addressed by Commonwealth government agencies.
- Non-government organisations recommended that guidelines be implemented before carbon dioxide geosequestration projects go ahead.
- Need for early establishment of science to ensure carbon dioxide geosequestration works. Need for transparency in the carbon dioxide geosequestration process. This view was shared by the government representatives present.
- Long term liability issues and which government would be responsible post closure. The draft principles as they stand however do not go into that level of detail as they are only at the first draft initial stage. Further consideration is needed regarding specific details of principles.
- Questions about the life cycles of projects and leakage rates were raised. The length of the life cycle of a project would be determined on a case by case basis; however work is still being done on how long the carbon dioxide can be contained in a formation. The draft principles do not go into enough detail to state the specific leakage rate that may be allowable. However, existing regulations will be considered as a starting point.

8. IMPLEMENTATION AND REVIEW

- Implementation of principles and future consideration of government regulation will be left to the discretion of each jurisdiction;
- Processes for amendment of regulation will be outlined; and
- The Ministerial Council on Minerals and Petroleum Resources should review the regulatory framework to ensure that it is effective and efficient in practice and the principles are being interpreted consistently.

ATTACHMENT A

Draft Regulatory Guiding Principles

- The Carbon dioxide Geosequestration Regulatory Reference Group has compiled a broad document titled Draft Regulatory Guiding Principles for Carbon Dioxide Geosequestration. This document focuses on seven key areas relevant to of carbon dioxide geosequestration. These are the principles that MCMPR have agreed to and they will be considered by stakeholders during consultation sessions.

The principles are as follows:

Access and Property Rights

Access to suitable geological structures for carbon dioxide geosequestration and to surface injection sites should:

- *be based on established legislative and regulatory arrangements, custom and practice;*
- *recognise and adequately account for the interests of other stakeholders, including existing and future surface and subsurface rights-holders; and*
- *accommodate the likely evolution of multi-user geosequestration infrastructure and facilities.*

Legislation granting surface and subsurface rights for carbon dioxide geosequestration should:

- *provide certainty to rights-holders of their entitlements and obligations;*
- *guarantee security of access over time and in relation to the volume of gas that may be stored; and*
- *define the "geosequestration gas" so that it can be legally injected into the storage site.*

In granting rights to inject carbon dioxide into subsurface formations, governments should give due consideration to land use planning issues likely to arise as a consequence of having carbon dioxide injected into that part of the subsurface.

Long Term Responsibilities

Responsibility and associated liabilities should remain with the project proponent until the relevant government is satisfied to a high degree of certainty that:

- *future land-use objectives defined at the time of project approval have been met;*
  the residual risks of leakage and liability are acceptably low; and
- *the ongoing costs associated with the site are acceptably low or are otherwise appropriately managed (for example through financial assurances, instruments and trust funds).*

Following closure, primary responsibility for the site will lie with government, although some residual liability may remain with the proponent.

The scope and nature of these residual responsibilities should be resolved upfront to the extent possible, recognising that responsibility depends on individual circumstances of each case. These liabilities should be determined and negotiated with the proponent on a project-by-project basis.

There may be a need to manage any residual liability that remains with the proponent e.g. through means such as ongoing indemnities, insurance policies or trust funds.

Environmental Issues

Regulation of carbon dioxide geosequestration should be based on a science-based assessment of the environmental risk, be based on best practice, be nationally consistent and be subject to regular review as new information becomes available.

Regulation of carbon dioxide geosequestration should aim to instil community confidence that the environment will be protected, provide industry with the certainty required to undertake projects, avoid overregulation that would unnecessarily impinge on project viability and be based as far as possible on existing regulatory frameworks.

Authorisation and Compliance

Existing legislation (Acts, Regulations, guidelines) such as those for chemical manufacturing, electricity generation, pipeline transportation, petroleum and mining exploration and development, environmental aspects, operational health and safety, storage of hazardous waste, that relate to activities under carbon dioxide geosequestration should be identified along with the parts of that legislation that applies to carbon dioxide geosequestration; and this existing legislation could be modified and augmented as needed to achieve an integrated carbon dioxide geosequestration framework.

National consistency should be aimed for in Commonwealth and State legislation relating to carbon dioxide geosequestration. There should be agreed national protocols and guidelines to be used by all jurisdictions. Commonwealth and State agencies should authorise carbon dioxide geosequestration activities and ensure compliance in their jurisdictions. A single industry code of conduct throughout Australia should be investigated.

Monitoring and Verification

For the purposes of monitoring and verification, a regulatory framework should:

- *Provide for the generation of clear, comprehensive, publicly accessible, timely and accurate information that is used to effectively and responsibly manage environmental, health, safety and economic risks and to ensure that set performance standards are being met; and*
- *Determine to an appropriate level of accuracy the quantity, composition and location of gas captured, transported, injected and stored and the net abatement of emissions. This should include identification and accounting of fugitive emissions.*

Transportation

The transport of carbon dioxide in pipelines has many similarities to the pipeline transport of chemical and petroleum products and therefore the same regulatory principles relating to access, safety and environment should apply. However where there are differences these must be recognised.

Similarly existing legislation should be applied and if necessary modified for the transport of carbon dioxide by road, rail and sea.

Financial Issues

Consistent with the need to create and maintain public confidence, all fiscal and regulatory measures must be subject to a least cost approach:

- *regulatory processes should preserve the international competitiveness of Australian industry;*
- *wherever practicable established regulatory principles and procedures should be used in preference to introducing new ones; and*
- *fiscal burdens imposed on any jurisdiction or industry as a result of regulatory processes or outcomes should be avoided wherever possible.*

Recognition should be made (e.g. via a policy statement) that the capital and operating costs of capture and storage can be substantially incorporated into the existing fiscal system and accounting principles framework on the same basis as existing business expenditure. Where changes need to be made, they should not discriminate against this form of investment.

It should be recognised that capture and storage technologies enable the generation of national, global and intergenerational public goods. Given that these technologies in their early stages are likely to be marginally commercially viable, consideration may need to be given to how these public goods are incorporated into commercial decision making so as to arrive at nationally optimal levels of investment and timing of new investment.

ATTACHMENT B

Environmental impacts and risks of CO_2 geosequestration

The environmental issues and risks associated with CO_2 and its interaction with the atmosphere, soils, water and the biota are relatively well understood. However further research and monitoring is required to fully understand the issues that may be associated with long term geological storage.

CO_2 is a naturally occurring constituent of the biosphere that is essential to all life forms. It is generally regarded as safe, however environmental impacts, including biological toxicity, may arise where CO_2 is present in unnaturally high concentrations. The degree of potential environmental impact depends on the degree of concentration and the characteristics of the receiving environment, including the composition of the biota in that environment.

Apart from climate change impacts, a CO_2 release to the atmosphere poses little environmental danger provided that it is able to disperse quickly to relatively normal concentrations. A hazard can arise if CO_2, which is denser than air, is allowed to accumulate in low-lying, confined or poorly ventilated spaces.

The environmental impacts of CO_2 in-situ in geological formations will depend on the chemistry of the formations and the integrity of the encapsulating structures. Potential chemical interactions between the CO_2 and the surrounding geology are the subject of ongoing research. However negative environmental impacts of CO_2 may not arise unless it migrates beyond the anticipated containment zone. Potential environmental impacts associated with migration beyond the containment zone would depend on where the CO_2 migrates to, over what time-frame and in what quantities. The possible impact on deep sub-surface nanobes has been raised as an issue and should be the focus of future research. Environmental issues requiring further clarification include:

- the potential implications of mixed gas streams (i.e. in the event of an unplanned release from either the capture, transport or injection stages of a CCS project);
- the long-term implications of CO_2 in-situ in geological structures;
- the environmental implications of CO_2 migration or escape from containment zones and the risk of these events occuring; and,
- the environmental implications of the storage of non-pure CO_2.

CO_2 capture stage

The technologies used for CO_2 separation or capture are well understood and used in a range of industrial processes. Although the Subgroup was unable to identify any issues that would differentiate the environmental risks of CO_2 separation/ capture for geosequestration purposes from gas separation for other purposes, a number of issues require further investigation. Issues requiring further investigation include the risks that might be posed by leaks at the capture point, the effect of mixed gases at the capture point and the impact of chemicals used in capture. The issue that may differentiate any risks at the capture stage of CCS projects from CO_2 capture/separation for other purposes is that of scale. However it is probable that plant safety rather than environment would be the primary issue at the capture stage.

CO_2 transport stage

The environmental risks associated with transport of CO_2 via pipeline construction activities would be similar for any pipeline carrying compressed gases (e.g. natural gas). Because CO_2 is heavier than air and toxic in high concentrations, the specific dispersion characteristics of CO_2 would require separate modelling to evaluate the pattern of potential impacts in the event of pipeline failure. The overall risks from pipeline transport are not significantly different from a range of pipelines already in operation. The environmental risks of transport of CO_2 by road, rail or ship would be similar or less than those arising from the movement of other compressed and liquefied gases.

CO_2 injection stage

The potential environmental impacts of wells drilled for CCS projects would be similar to those for oil and gas wells. There may be subtle differences in the requirements for compressor stations and related infrastructure. The potential for gas cloud releases to be undetected if injection fails may be increased for CO_2 due to its non-odorous nature, however this risk can be easily managed with adequate monitoring at the injection point.

CO_2 storage stage

Potential impacts of CO_2 storage in a geological structure are related primarily to the potential for it to escape over time. The leakage of CO_2 may possibly occur via pre-existing faults and fissures or as a result of pressurisation of the structures. It is currently difficult to quantify with confidence the likelihood of unplanned releases of CO_2 from geosequestration sites. This is due to the lack of detailed research and field trials into CO_2 geosequestration and the difficulty of assigning generic risks to situations that are likely to vary considerably from site to site. Further research combined with test work and trials of specific reservoirs will need to be conducted to enable risk profiles, and eventually quantitative risk estimates, to be made.

There is a slight risk of CO_2 migrating out of the storage reservoir and into one or more surrounding geologic formations. This in turn could result in the contamination of freshwater aquifers, and/or interference with the activities at producing oil/gas reservoirs or coal mines. In the case of CO_2 injection into deep saline formations, there is also the small possibility that displaced brine could contaminate groundwater. The contamination of freshwater aquifers could be caused by vertical migration of stored CO_2. Buoyancy forces, caused by the density difference between the injected supercritical CO_2 and the formation waters, will tend to drive stored CO_2 upward. If the formation is not a geologic trap or not adequately sealed by an impermeable caprock, CO_2 could leak from the storage reservoir.

There is then the potential for the vertically migrating CO_2 to dissolve in shallow aquifer waters, form carbonic acid and lower the aquifer water pH, which in turn could result in the mobilization of heavy metals and/or the leaching of nutrients. In a worst-case scenario, the contamination of a freshwater aquifer could exclude its use for drinking or irrigation supplies. CO_2 migration within the subsurface also has the potential to contaminate energy and mineral resources as well as pose an occupational safety hazard for mining and exploration activities. While there are still uncertainties with regards to CO_2 migration, significant advances in understanding fluid behaviour and formation integrity have been made. Further, enhanced oil recovery (EOR) operations using CO_2 floods have experienced no significant losses of CO_2 to other subsurface zones and as such give us some confidence that CO_2 migration risks may be low. At the same time, however, it is to be noted that EOR activities cannot simulate the movement of CO_2 over the time frames required for effective storage.

Groundwater contamination could also result from the displacement of brine in the case of CO_2 injection into deep saline formations. Brines displaced from deep saline formations by injected CO_2 could, potentially, contaminate shallower freshwater aquifers by increasing their salinity and thereby make them unsuitable as a source of potable water. In the worst case, infiltration of brine into groundwater or the shallow subsurface could also restrict or eliminate agricultural use of land and/or impact wildlife habitat. It is to be stressed, however, that North American experience with deep well injection of fluids, at rates roughly comparable to the rates at which CO_2 would be injected if geosequestration was widely adopted, has found that groundwater contamination from brine displacement is rare, and that one may therefore expect that contamination arising from large-scale CO_2 storage activities would also be rare.

Health and Safety Risks
The risk to humans from the pipeline transport, injection and storage of CO_2 as part of geosequestration projects would be minimal. The transport of CO_2 by pipeline and the injection of CO_2 into geologic reservoirs has been occurring for many years in the United States, as well as in some other countries, as part of enhanced oil recovery (EOR) and acid gas injection (AGI) operations. This experience has led to the tools and expertise needed for CO_2 pipeline transport and CO_2 injection to be managed safely.

The health and safety risks associated with CO_2 storage, although considered small, are characterised by a greater degree of uncertainty. This is first due to the fact that once the CO_2 enters the geologic reservoir, its fate is transferred from largely human control to a natural system. Second, unlike for CO_2 pipeline transport and CO_2 injection, EOR using CO_2 floods and AGI do not provide a great level of understanding or expertise in safe and effective management of CO_2 storage; the quantities of CO_2 stored are smaller and the time periods involved are shorter than required for geologic carbon sequestration.

Through the development of improved models of the long-term behaviour of CO_2 in reservoirs and the study of analogues such as natural CO_2 deposits, scientists are however gaining a better understanding and further minimizing the risks of CO_2 storage. It should be noted that the potential health and safety impacts associated with a CO_2 leak from the offshore CO_2 pipeline transport, injection and storage will be negligible, although there is the possibility of minimal damage to the local marine environment.

Carbon dioxide (CO_2), a naturally-occurring constituent of air that is essential to all life forms, is a non-toxic, inert gas and is generally regarded as safe. At elevated concentrations, however, CO_2 can cause harm to humans. The effects of elevated CO_2 levels depend not only on the concentration but also the duration of exposure. The ambient concentration of CO_2 in the atmosphere is currently about 370 parts per million (ppm) or less than 0.04%. For humans, there are no adverse health effects for CO_2 concentrations up to 3%. While some discomfort occurs for concentrations between 3% and 5%, it is only for concentrations above 5% that there are serious, possibly fatal, consequences. At concentrations above 25% to 30%, loss of consciousness occurs within several breaths and death quickly thereafter.

The risk of a CO_2 leak from a pipeline and then humans being exposed to harmful levels of CO_2 is very minimal. According to the United States Department of Transportation's Office of Pipeline Safety, onshore pipeline failure most often occurs as a result of external activities such as construction and farming. In the case of onshore pipeline failure, the amount of CO_2 escaping will be limited by the use of gas detection and pressure monitoring systems, and automated shutdown valves. Typically, the escaping CO_2 will then be diluted to safe levels by entraining air within minutes of the release. It is to be noted that, since 1990, there have been no injuries or fatalities associated with incidents involving CO_2 pipelines in the United States.

The potential risk to human health and safety from CO_2 injection is primarily of an occupational nature. The most common cause of CO_2 exposure during the operational phase is well-head failure that results in CO_2 leakage. In the majority of cases, the problem is quickly identified and the well promptly repaired or plugged. A threat to worker safety would occur where the leak went undetected and CO_2 was allowed to accumulate in a confined space. While such incidents may pose a safety risk to workers in the immediate vicinity of the well, the risk to the general public should be considered negligible. Well failure of this type is most often caused by poor engineering practices.

It is possible, though quite unlikely, that slow releases of CO_2 from a geologic CO_2 storage site could pose a safety threat. Potential sources of slow CO_2 leaks include transmissive faults or fractures, poorly sealed injection wells and incompletely plugged abandoned wells.

The majority of leaks such as these are likely to go unnoticed as they diffuse in the atmosphere in similar fashion to CO_2 fluxes from natural earth degassing, biological respiration and organic matter decomposition. Nonetheless, there is the slight possibility that certain topographies or confined structures may act to concentrate the CO_2 to dangerous levels.

There are three main concerns associated with geosequestration in terms of health and safety:

1. The transport of CO_2 by pipeline presents a potential safety hazard to workers and the general public (negative externality).
2. The injection of CO_2 into a geologic reservoir presents a potential safety hazard to workers (negative externality).
3. The storage of CO_2 in a geologic reservoir presents a potential safety hazard to the general public (negative externality).