CARBON
STORAGE
TASKFORCE

SEPTEMBER 2009

Australia's Potential for the Geological Storage of CO_2

Australia has sufficient geological storage capacity to make carbon capture and geological storage (CCS) a real option in the portfolio of responses needed to reduce Australia's greenhouse gas emissions.

This was the key finding of the Carbon Storage Taskforce in its report, the *National Carbon Mapping and Infrastructure Plan—Australia* (the Plan). This analysis focuses on the transport and storage aspects of CCS and sets out the work that needs to be done before Australia could be considered 'storage-ready'.

INTRODUCTION

CCS is currently the only technology recognised as being capable of dealing with large quantities of CO_2 emissions from stationary emitters[1]. Approximately 20% or 120 million tonnes per annum (Mtpa) of Australia's future CO_2 emissions could be avoided, by capturing the CO_2 from ten 'hubs' or clusters of emitters.

The large scale deployment of CCS depends on identifying and developing suitable storage sites for CO_2. In Australia, most of these sites will be aquifers and will take around 11 and 13 years to develop, with a focussed program that is actively pursued and adequately funded.

The demonstration of CCS at a significant scale is essential to build investor confidence in the technology. In Australia, several demonstration storage sites could be ready by 2018, and two to four large-scale integrated CCS projects are being supported under the A$2 billion CCS Flagships Program.

If Australia is to realise the opportunity for commercial deployment beyond 2020, current geological and engineering activities must be accelerated and maintained over the next decade.

AUSTRALIA'S PROJECTED FUTURE EMISSIONS

Australia's net total greenhouse gas emissions in 2006 were 576 Mt CO_2e. The energy sector was the largest source of greenhouse gas emissions at just under 70% of the total (401 Mt). The largest emission contributor to the energy sector is stationary energy, which made up 50% of Australia's emissions in 2006. The vast majority (99.2%) of stationary energy emissions are CO_2.

Emissions from electricity generation are projected to reduce from 72% of Australia's total stationary emissions in 2010 to 56% in 2020. This is expected to be offset by an increase of emissions related to Liquified Natural Gas (LNG) from 3% in 2010 to 20% in 2020, owing to new developments coming on stream. Other sources of concentrated emissions such as aluminium, alumina, steel and iron ore, cement and petroleum refining remain relatively constant.

THE TASKFORCE

The Carbon Storage Taskforce was established by the Australian Government in mid-2008 to develop a plan to drive the prioritisation of, and access to, a national geological storage capacity to accelerate the deployment of CCS in Australia.

The Taskforce brought together key industry sectors and stakeholders, including coal, power generation, oil and gas, pipeline operators, geological survey agencies, unions, NGOs, and Commonwealth and state governments.

The Taskforce concluded its work in June 2010. This summary is drawn from its report, the *National Carbon Mapping and Infrastructure Plan – Australia*.

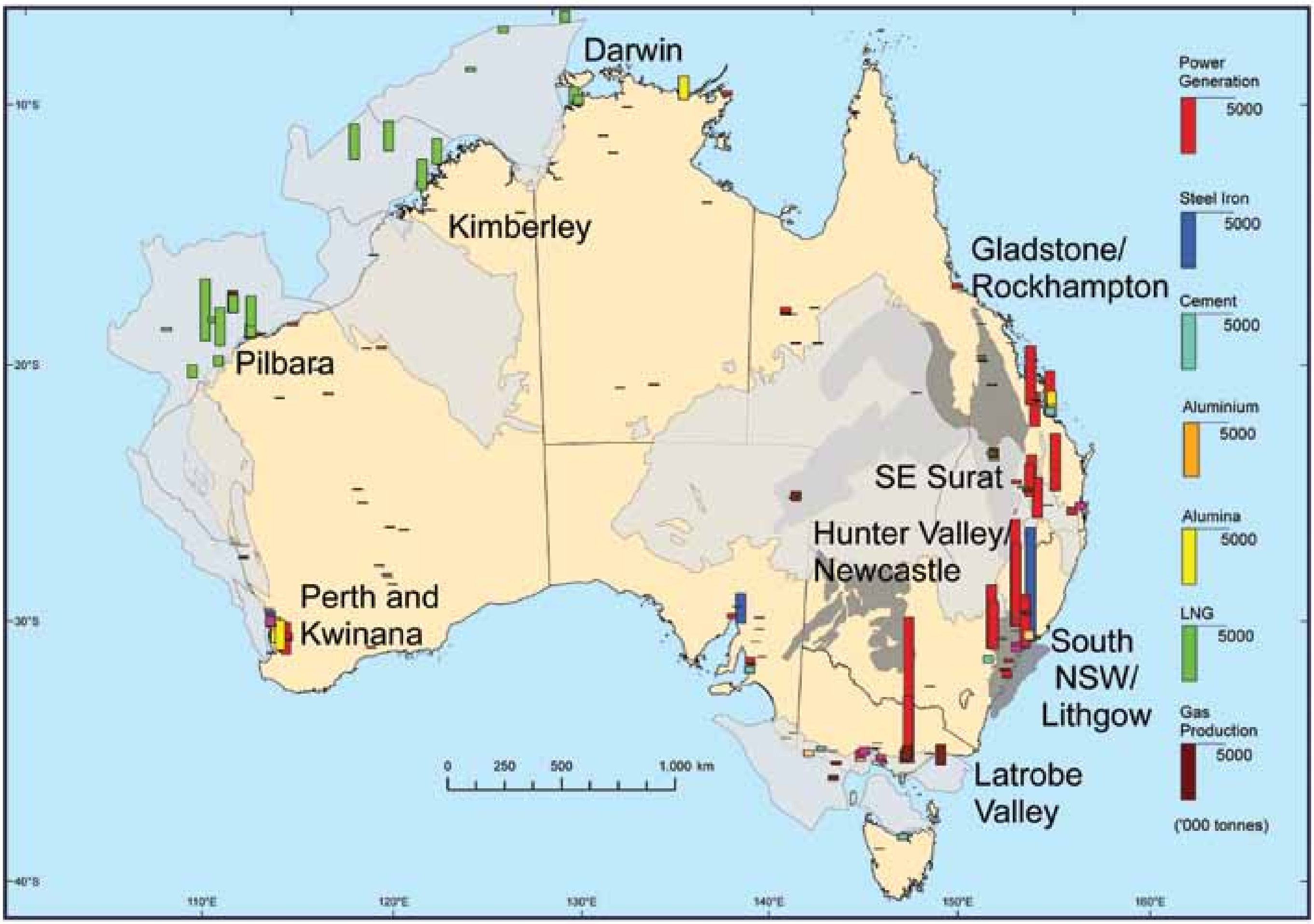

Figure 1: Australia's projected stationary emissions in 2020 by industry

Where emitters are, or are likely to be, located close together, it will be more economical and efficient to establish hubs for the transport to, and storage in, large CO_2 geological storage sites. Figure 1 shows the ten hubs across Australia that have been identified by the Taskforce.

POTENTIAL STORAGE SITES

The CO_2 volumes to be stored annually in Australia are large (in the order of 200 Mtpa) and some storage basins may need to store up to 50 Mtpa.

Sedimentary Basins

Australia has many sedimentary basins that could potentially be used for the storage of CO_2. Some basins are well known and explored, while little is known about others. There are large thick basins along the north western, western and southern continental margins. The onshore basins with significant sedimentary thickness are concentrated in the central east of Australia with one basin in the west.

The Taskforce carried out a technical ranking of these basins, using a high-level, qualitative approach that accounts for this diversity in understanding.

As shown in Figure 2, eleven basins are regarded as having the best potential for storage, with a further series of basins identified as having possible storage potential or are of strategic importance.

Oil and Gas Fields

The CO_2 storage capacity of Australia's oil and gas fields is estimated to be approximately 16.5 gigatonne (Gt). The vast majority of this is offshore (~15.6 Gt). The northwest of Australia contains ~13.4 Gt of storage capacity. However, these fields are distant from the emitters in southwest and eastern Australia and will still be in use for oil and gas production for many years.

If Australia is to realise the opportunity for commercial deployment beyond 2020, current geological and engineering activities must be accelerated and maintained over the next decade

The oil and gas reservoirs in the Bowen and Surat basins in southeast Queensland have been depleted and are well situated to match local small-volume CO_2 sources. However, there may be competition for these reservoirs as they are also an ideal storage buffer for coal seam gas extracted for use in proposed LNG projects.

Several oil fields in the prolific oil and gas producing Gippsland Basin appear to be at or near the end of their productive life. These have potential to hold large volumes of CO_2 but the transition from petroleum recovery to storage activities needs to be carefully managed. The larger gas fields have productive lives that could extend beyond 2050.

Australia's CO_2 storage capacity is estimated to be 417Gt, equivalent to around 2000 years of storage

AUSTRALIA'S POTENTIAL STORAGE CAPACITY

Using conservative assumptions for storage efficiency[2], Australia's CO_2 storage capacity is estimated to be 417 Gt. This is equivalent to around 2000 years of storage, at an injection rate of 200 Mt per year.

There is a high confidence that the east of Australia has aquifer storage capacity for 70 - 450 years at an injection rate of 200 Mtpa, and that the west of Australia has capacity for 260 -1120 years at an injection rate of 100 Mtpa.

As more becomes known about the basins and their CO_2 storage behaviour, it is possible that far greater capacity will be defined

SOURCE-SINK MATCHING

Matching CO_2 sources with the basins where the CO_2 will be stored (know as 'sinks') is important in determining the economics of deploying CCS.

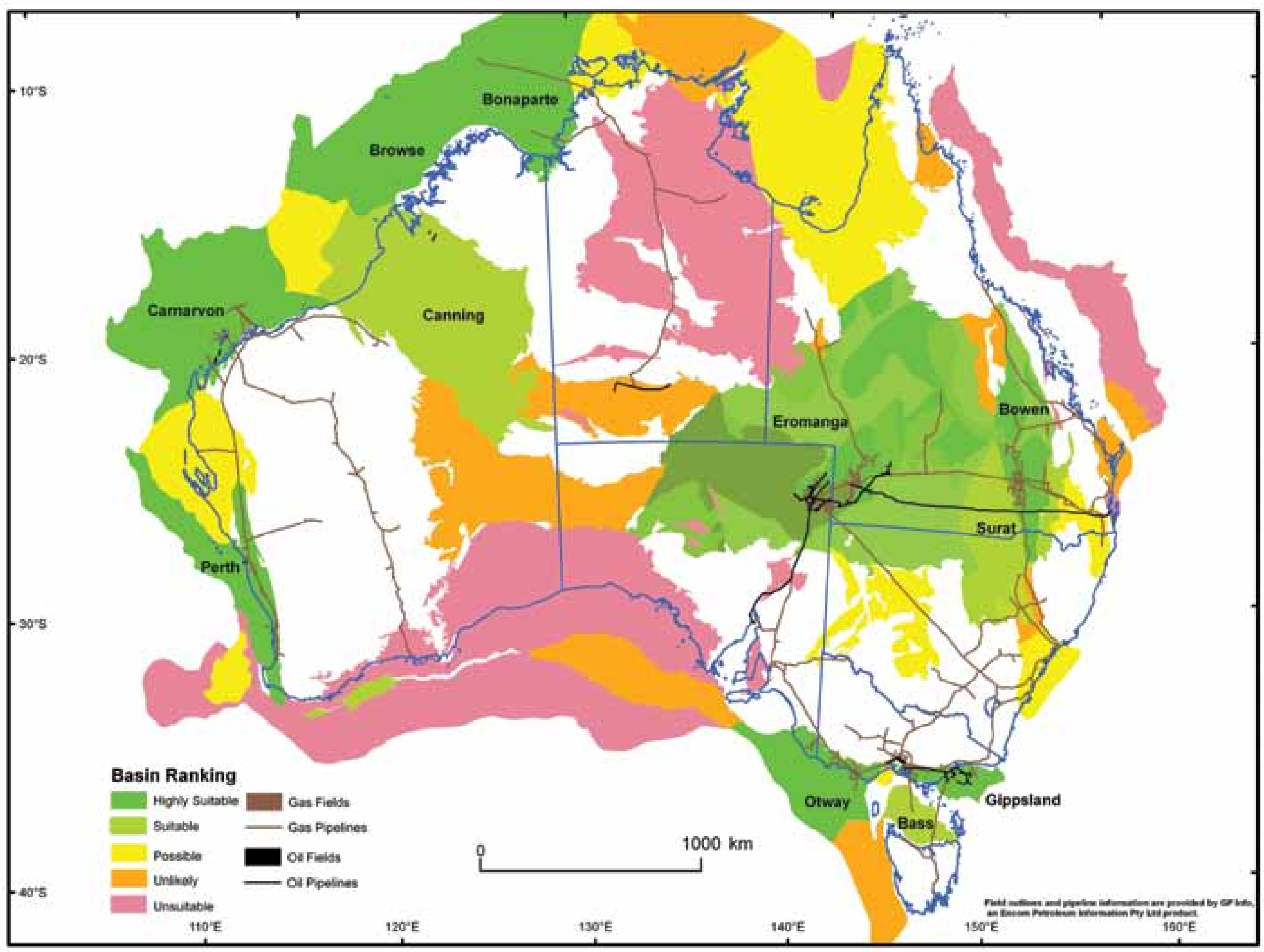

Figure 2: Australia's basins ranked for CO_2 storage potential

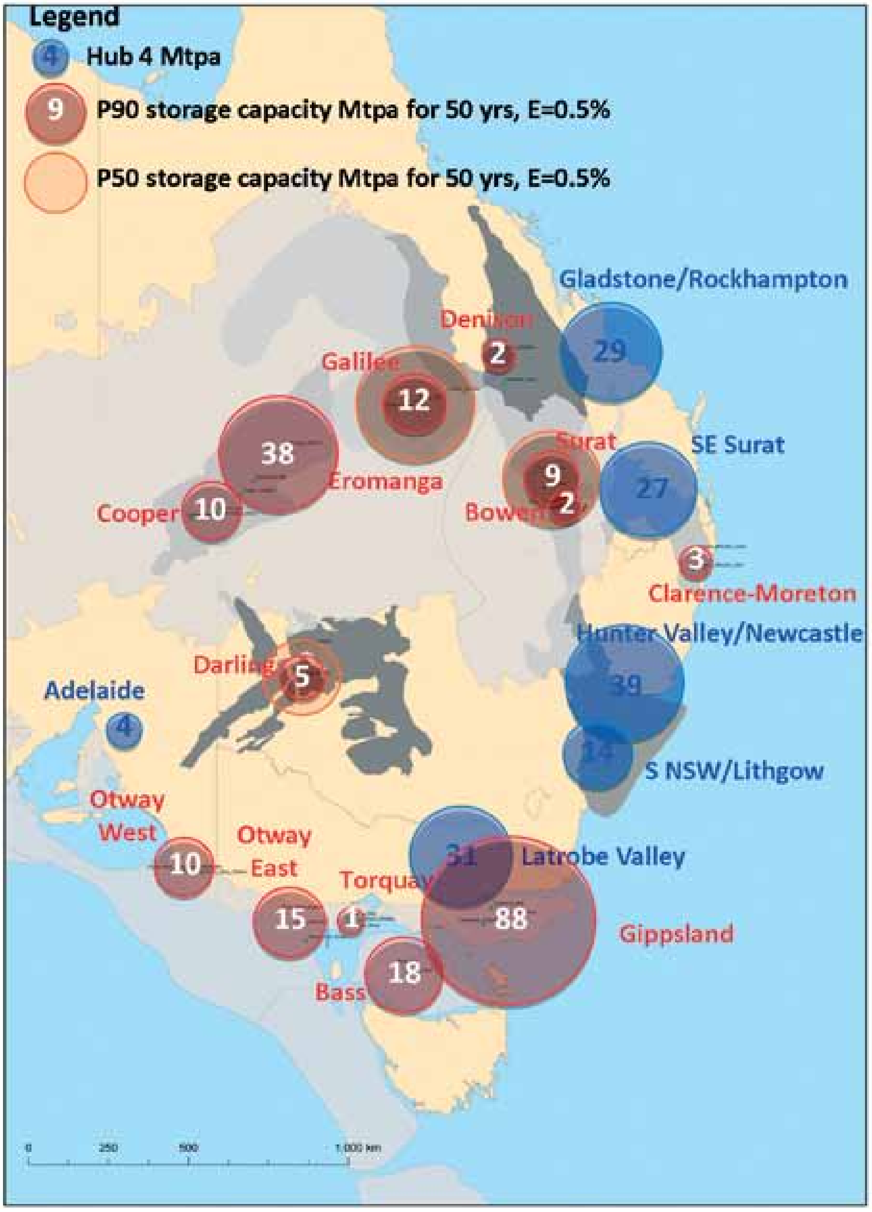

Figure 3: Eastern seaboard source-sink matching

The East of Australia

Figure 3 shows the source-sink matching for eastern Australia. The blue circles represent the six major emission hubs, with the size of the circles reflecting the magnitude of emissions. The red circles represent the main basins or sinks, with the size of the circle proportional to the storage capacity of the basin (in Mtpa CO_2 for 50 years of injection).

The Gippsland Basin has the greatest capacity of the eastern basins. It is also very close to the Latrobe Valley hub (150km). From a purely technical point of view, it is the first choice for the development of a long-term storage basin in Victoria. The Bass Basin is the alternative storage basin for Latrobe Valley emissions.

In South Australia, the Otway West Basin is the likely storage site for the Adelaide hub. The Cooper Basin could be used for the storage of reservoir CO_2 associated with the production of domestic gas from the Cooper and Eromanga basins.

In Queensland, the Eromanga Basin has the greatest capacity, but is more than 1,200 km from the emissions hubs. Storage in this basin would incur significant transport costs. The closer Surat and Galilee basins (400-600 km) have storage capacity that could be used for the first 25 years as a stepping stone to Eromanga. The Denison Trough only has small-scale potential.

The New South Wales basins are relatively unexplored, but on the current data available, the majority of the basins have low storage capacity. The one possible exception is the Darling Basin, a large basin (by area) located in central west New South Wales, but considerable extra data would be needed to confirm this.

As more becomes known about the basins and their CO_2 storage behaviour, it is possible that far greater capacity will be defined

The West of Australia

Figure 4 shows the source-sink matching for the west of Australia, which indicates four potential hubs.

The most likely storage basins for the Perth and Kwinana hub emissions are the onshore and offshore North Perth Basin. In addition to aquifer storage, the onshore North Perth Basin is attractive as the initial storage location because it has a number of depleted gas fields as potential storage locations.

CO_2 emissions in the Pilbara region are projected to increase as new LNG and domestic gas projects come on line. The Carnarvon Basin is expected to be the storage location.

Significant emissions are projected for the Kimberley region as a result of the possible development of a LNG hub to the north of Broome. The onshore Canning Basin may be the preferred storage location.

The majority of emissions from the Darwin Hub are also associated with LNG production. Reservoir CO_2 could be transported to the nearby offshore Bonaparte Basin for storage.

INFRASTRUCTURE REQUIREMENTS

The generally long distances between emissions hubs and storage basins mean that more than 5,000 km of large diameter pipeline infrastructure is needed to transport CO_2. This is more than three times greater than Australia's current inventory of large diameter steel pipeline.

Australia has extensive high-pressure gas transmission pipeline infrastructure, but it is privately owned and currently in use conveying hydrocarbons. In any case, the cost of converting these pipelines for CO_2 transportation would be similar to the construction costs of a new pipeline.

Pipelines are subject to regulation under the Australian Standards (AS). AS2885 is the most appropriate standard for CO_2 pipelines but has not yet been extended to cover it specifically. Research to inform the amendments necessary to the standard is currently underway.

Pipeline construction will be a key element of CCS project timelines. For the first CO_2 pipelines to be built in Australia, it is expected that the process to reach Final Investment Decision will be protracted, and could take up to 36 months. Development could take 3 - 6 years. Once the construction phase has commenced, a typical pipeline project can achieve construction rates of up to 4km per day.

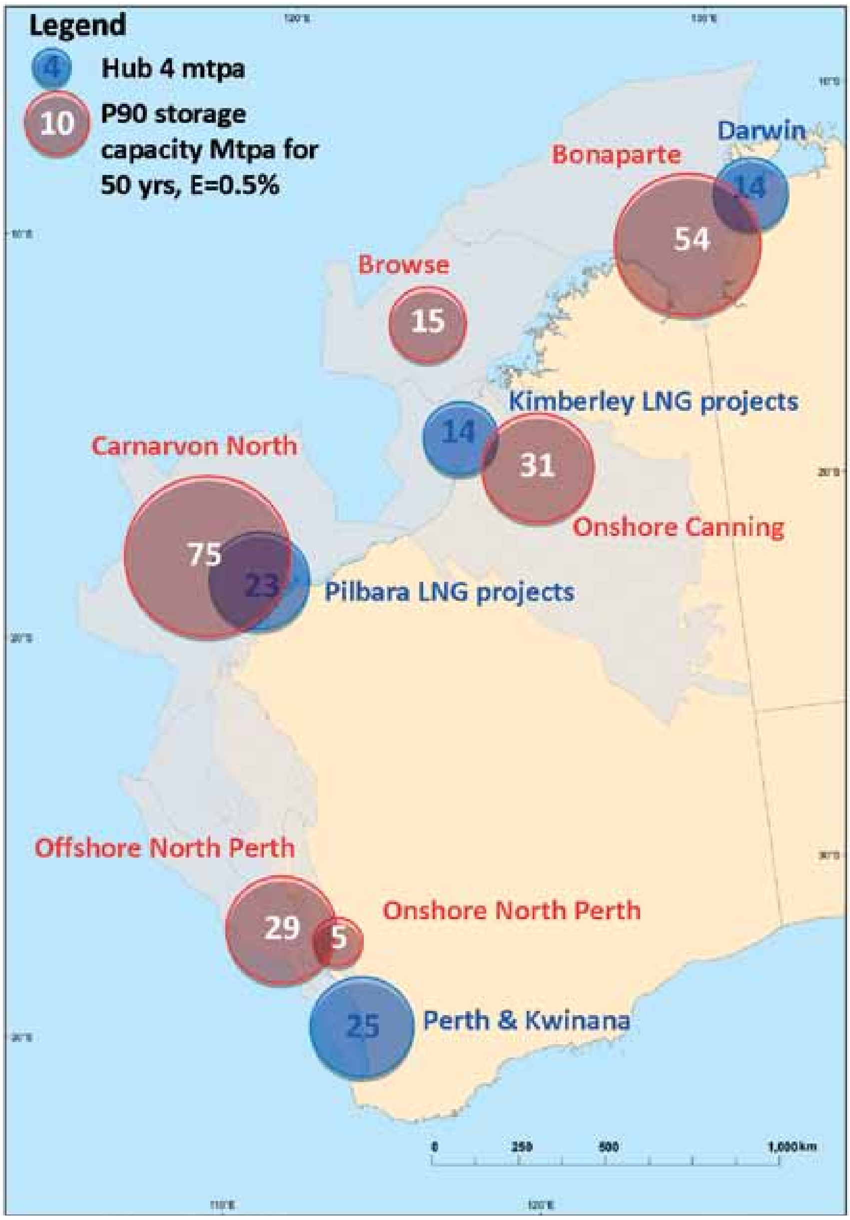

Figure 4: Western seaboard source-sink matching

ECONOMIC COMPARISONS OF HUB-BASIN COMBINATIONS

The main factors affecting the economics of CO_2 storage are:

- location, as the distance from the CO_2 source to the storage location determines pipeline costs;
- reservoir depth, which influences well costs; and
- injectivity parameters, which determine the number of wells needed.

Transport and storage tariffs vary widely for different combinations of hubs and basins, as shown in Figure 5. Preliminary tariff estimates for transport of large quantities of CO_2 from the Latrobe Valley to Gippsland Basin storage sites range around $10 per tonne of CO_2 avoided, compared to around $30-$60 per tonne of CO_2 avoided for CO_2 transported from central east Queensland to the Eromanga Basin.

For the power generation sector, this translates to an additional $1-$10 per megawatt hour (MWh) for electricity generation costs, dependent on location.[3]

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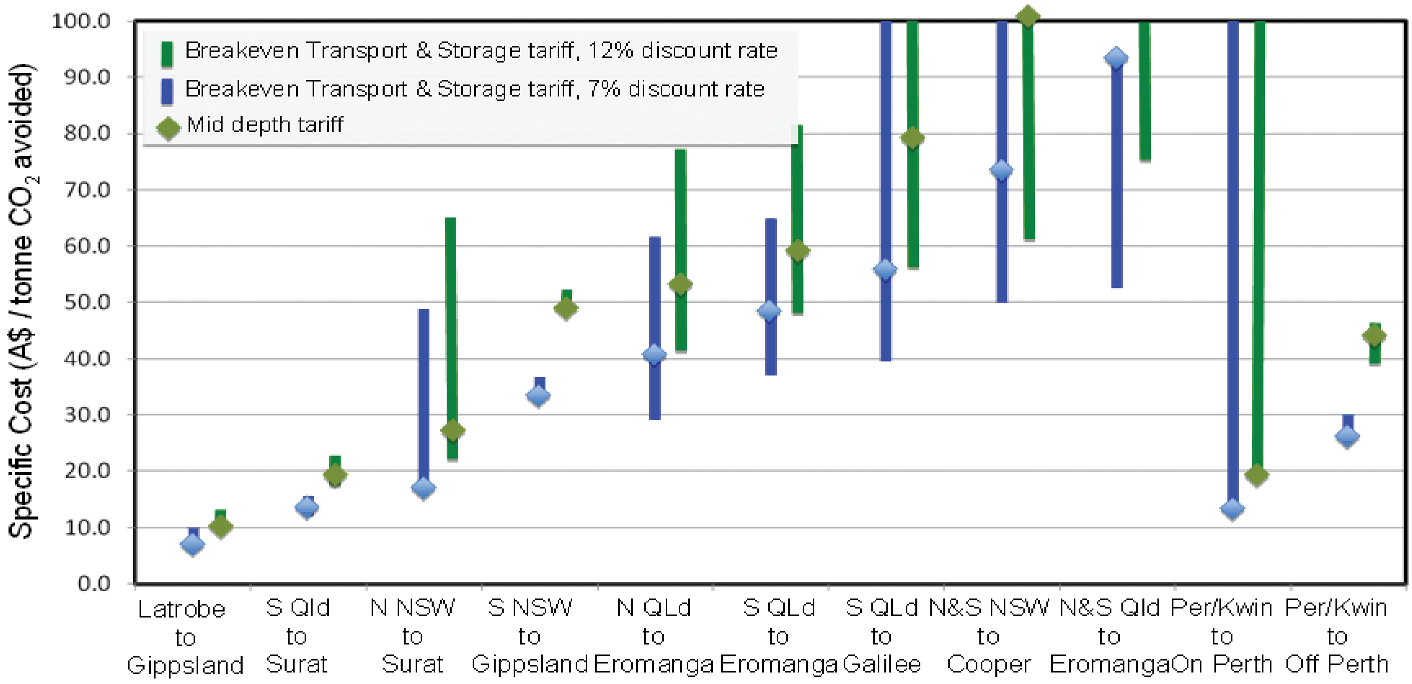

Figure 5: Break-even transport and storage tariffs for hub-basin combinations

The different CO_2 transport and storage costs will be a key factor in the optimal location of new plant, and new energy generation hubs may emerge. For example, locating new generating plant close to the Surat Basin storage areas would reduce the transport and storage tariff by more than 50%, to levels comparable with the Latrobe Valley to Gippsland Basin.

The impact of the different carbon transport and storage tariffs on the National Energy Market has been modelled. For a carbon price scenario rising to $127 per tonne of CO_2 by 2050, generation from existing plant is expected to peak in 2020 and then progressively decline as new power generation plants enter the market.

Creating investor confidence in CCS will be critical

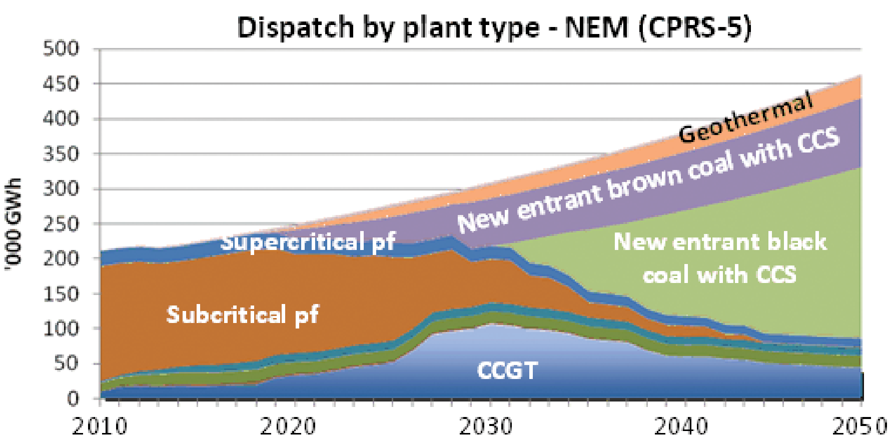

Figure 6: Electricity dispatch by plant type

Figure 6 shows that new entrants are projected to provide 73% of generation in 2050. Initially, new entrants are likely to locate in the Latrobe Valley (brown coal), due to the lower cost of carbon transport and storage in the Gippsland Basin. A slower uptake of CCS in NSW and Queensland (black coal) is likely, due to higher carbon transport and storage costs.

OTHER CONSIDERATIONS AFFECTING CCS DEPLOYMENT

A range of other factors need to be considered in the deployment of CCS:

Impact on the use of other resources

CO_2 storage operations may be located in basins where other resources such as fresh water, petroleum, geothermal heat, coal seam methane and coal are, or will be, developed. The impact of CCS activity on other resources and operations will need to be assessed for each case.

Policy uncertainty and carbon price

This will be a key factor in investors' perception of risk for projects that require returns on assets over several decades.

Technological obsolescence

To reduce costs through economies of scale, large scale investments will be required. This, however, creates a risk that the technology will become obsolete during the life of the project.

Public Acceptance

The deployment of CCS in Australia relies on community acceptance, particularly in onshore areas and in relation to pipelines. Some key concerns from community members include:

- *Funding*: some perceive that funding for low emissions energy technologies disproportionately supports coal-fired power, rather than renewable energy technologies.
- *Technology*: many over-estimate the role that solar power and renewables can play, misunderstanding their current capacity to meet energy demand, and the full costs and risks of deploying these technologies relative to alternatives.
- *Impact on power costs*: generally, there is limited understanding that the introduction of low emissions energy technologies will make power costs in Australia more expensive.
- *NIMBY (Not In My Back Yard)*: to date, CCS projects in Australia have engaged well with communities and other stakeholders that may be affected. Internationally, however, some projects are meeting strong local resistance.

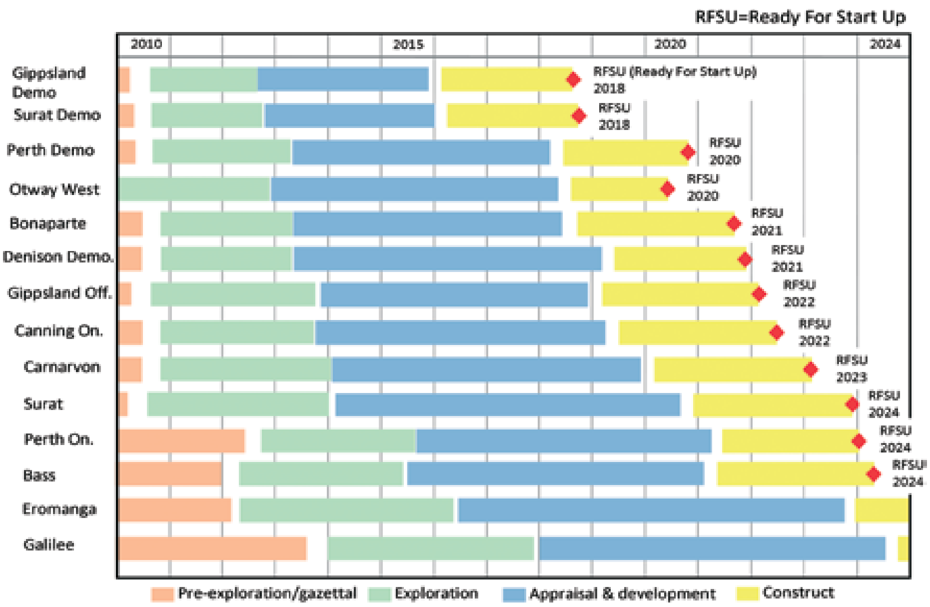

Figure 7: Timing from pre-exploration to the commencement of storage operations for likely storage basins and demonstration areas

The timeframes for the commercial deployment of CCS are long

TIMEFRAME TO GET SITES READY FOR STORAGE

The timeframes for the commercial deployment of CCS technology are long, and depend significantly on the identification and development of suitable storage reservoirs.

The Taskforce has estimated the time required to mature sites for storage, from pre-exploration to the commencement of storage operations. Figure 7 shows the timing, for likely storage basins and demonstration areas.

This timing assumes typical levels of investment, activity, and resource availability, and importantly, that the activities are sequential (e.g. drilling takes place once seismic is acquired and interpreted). The time could be shortened by using multiple drilling rigs for example, or by overlapping activities such as seismic and drilling. However, this incurs greater risk. The time would also be shortened if smaller scale injection was anticipated.

SCALE OF THE CHALLENGE

The level of exploration, development and infrastructure activity needed to create Australia's transport and storage capacity for CCS appears manageable. The projected level of activity required will be similar to current oil and gas activity levels.

While CO_2 transport and storage has many parallels with oil and gas, it poses challenges that require a different approach and mix of skills and knowledge for industry and authorities.

The full scale deployment of CCS will create significant competition for resources, geological sites and a skilled workforce. It will also require a significant investment in pipeline infrastructure to transport CO_2.

Further research and development on pipelines is needed, to assure the Australian community and its regulators that CO_2 can be transported safely and securely.

Creating investor confidence in CCS will be critical. Potential investors and the financial community consider that only demonstration at large scale (greater than 1 Mtpa) will be sufficient to build the confidence and knowledge needed to invest in full scale storage.

Demonstration projects also need to link capture, transport and storage elements so that the risks associated with the operability of the overall integrated system can be understood and addressed.

WHAT AUSTRALIA NEEDS TO DO TO BE 'STORAGE-READY' BY 2020

The *National Carbon Mapping and Infrastructure Plan – Australia* sets out, cohesively and in detail, what will be required for Australia to be 'storage-ready' by 2020.

Immediate efforts need to be focussed on six key areas:

- Pre-competitive exploration;
- Strategic release of exploration acreage;
- Demonstration projects;
- Pipeline infrastructure;
- Incentives for CO_2 storage exploration; and
- Communications and community education.

Further Information

The report, and additional information, is available online at www.ret.gov.au/cstf

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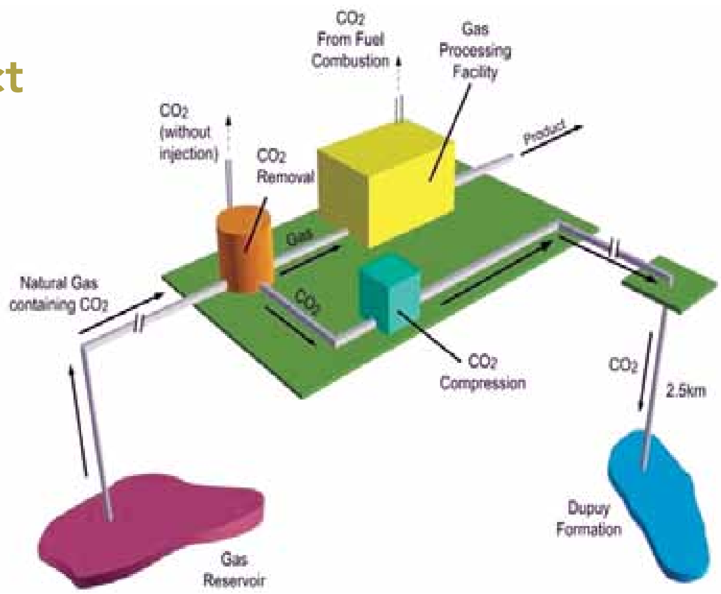
The Gorgon LNG Project

The deployment of greenhouse gas storage technology in Australia, at large scale, will first be achieved by the Gorgon Project in northwestern Australia.

The Gorgon Project aims to store some 3.5 Mtpa of CO_2 in the Dupuy Formation under Barrow Island and will be the largest storage project in the world. It was sanctioned in September 2009.

The Gorgon Project represents a critical step towards demonstrating the viability of large-scale commercial storage of CO_2.



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1. Stationary emitters: fixed or stationary emission sources typically from fuel combustion to provide energy in energy industries, especially electricity generation; manufacturing industries and construction; and other sectors.
2. Assumptions: probabilistic estimate, 50% confidence, assuming a storage efficiency factor (E) of 4%.
3. This does not include the costs for the new upstream generating and capture capacity. Neither the cost of capture nor the capital charges associated with the new power generation technologies are included in these tariff estimates. They refer to transport and storage only.