

The background of the entire page is a photograph of a shale gas wellhead. The structure is a complex of white metal beams, pipes, and valves, extending vertically from the bottom left towards the top right. The sky is a clear, bright blue. The wellhead is surrounded by various cables and mechanical components.

SHALE GAS IN AUSTRALIA: THE POLICY OPTIONS

GREEN PAPER

UCL International Energy Policy Institute
Adelaide, AUSTRALIA

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About UCL Australia

University College London (UCL) is one of the world's leading research universities. Founded in 1826, UCL was the first London university. In 2010 it became the first major British university to establish an international campus, opening UCL Australia in the South Australian capital of Adelaide. UCL Australia has three academic units; the UCL School of Energy and Resources, Australia; the UCL International Energy Policy Institute; and the Mullard Space Science Laboratory (Australia).

UCL Australia was founded with major funding donations from Santos, BHP Billiton and the Government of South Australia. It draws further funding from private and public programmes and a number of power and energy companies.

About the IEPI

University College London established the UCL International Energy Policy Institute (IEPI) in 2012, giving it a mission to consider global issues surrounding investment in power generation technologies where liberalised power markets are operating under carbon constraints.

This focus includes the complex interactions and implications of technical, legal, financial and environmental effects on power generation. IEPI also examines the role of governments in energy technology investment and the positive and negative impacts on resource-rich nations – including the 'resource curse'.

Value-adding to energy resources and assets, particularly global uranium production, the unconventional gas revolution and renewable energy, are also focal points for the research programme – particularly the impact of policy setting on communities, the environment and energy transmission.

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Executive summary

Australia has substantial unconventional gas resources.

However, unlike the US shale revolution, which is now well established, Australian states and territories are yet to collectively answer the question as to how far they want to exploit these unconventional assets. This is especially true within the portfolio of “shale gas deposits” (a term being used that also includes other formations, such as tight sands).

Currently, there are a number of diverse and non-specific regulatory measures that companies involved in the nascent shale gas industry are operating under, some with more success and openness than others. Furthermore, following the Australian federal election on 7 September, 2013, the new Industry Minister Ian Macfarlane moved quickly to encourage resource companies to ‘use or lose’ their development rights and committed to a new Energy White Paper within a year. Hence, this green paper focusses exclusively on the specific shale gas component of the Australian picture by considering the characteristics of international shale developments, including the US, to provide considered thinking for resource stakeholders in the new public policy debate. A major recommendation is that, for Australia to realise its shale gas potential, the regulatory regime should be reconsidered and refocused to provide a greater degree of clarity, transparency and community engagement.

Geology

This green paper provides a special section on geology, since the Australian shale geology is unique, challenging and, on the whole, not naturally conducive to familiar shale extraction technologies. It accepts that while the geology cannot be changed, there are opportunities for policy to enable improvements in recovery that can enhance its commerciality.

Policy

This green paper suggests that, in addition to geology, there are three substantial policy issues to be addressed should Australia wish to expedite its shale gas development. This includes creating:

1. *a larger and more competitive service industry;*
2. *improved gas pipe connectivity and access and;*
3. *wider community engagement and more inclusive governance frameworks.*

This green paper finds that a well constituted shale gas industry could lead to reduced greenhouse gas emissions and increased energy security. The use of shale gas for Australian electricity generation could reduce the projected CO₂ emission level for 2020 by about 14 per cent. The involvement of more shale gas operators could lead to an increase in domestic gas supply. However, the success of the shale gas industry will largely depend on collaboration between industry, governments and local communities. Finally, the development of a shale gas service industry could, given the large shale gas interest in Asia, provide a valuable source of export revenue for Australia.

This green paper suggests 10 areas for debate:

1. *State and Territory governments should fund the greater use of seismic (2D and 3D) data banks to verify lucrative areas for shale gas production and use this and a “use it or lose it” focus to prioritise shale gas projects based on the best resource basins.*
2. *The development of a larger and more competitive service industry for drilling and fracking should be encouraged, by offering a more attractive tax regime, including altering capital allowances and depreciation.*
3. *The acute shortage of deep well “proppants” (used to keep channels propped open to allow trapped oil and gas to escape) and “guar gum” (thickening agent) could be mitigated by stimulating domestic supply industries, again through taxation instruments, including accelerated depreciation of capital investment.*
4. *The disclosure of fracking fluids could be published publicly on a well-by-well basis, to enhance transparency and accountability.*
5. *The formation of knowledge sharing alliances among developers and service companies could be encouraged through investment and other fiscal measures. This may increase the speed of technology developments and the sharing of excessive cost burdens and secure the supply of gas for domestic consumption. The Australian Government’s new Exploration Development Incentive is one step towards this goal, enabling small and emerging gas producers to attract investment. The road mapping exercise in South Australia (bringing stakeholders together at targeted round-table meetings) could be duplicated by other states and territories. Similar alliances between emerging gas producers and manufacturers may also go some way to securing gas for domestic consumption, thereby securing jobs in the manufacturing sector, while avoiding a reservation policy.*
6. *Third party access to existing pipeline infrastructure could be improved by the implementation of a common carriage policy obligating pipeline owners to distribute the existing pipeline capacity on a pro rata basis, even if it is fully utilized.*
7. *The development of a stronger wholesale market, by implementing a trading platform for unused pipeline capacity, could simplify gas transactions. Furthermore, this may enable the transmission of gas directly from producers to consumers, leading to cost reductions.*
8. *Regulatory measures specific to shale gas operations should be contemplated in regards to environmental impact management and community engagement. Disparate legislation should be pulled together under a specific regime to aid transparency and ensure the effective governance of shale gas operations across Australia.*
9. *Obtaining social licences to operate with wider local community participation is vital for any long term shale gas industry. The collaboration and understanding of stakeholders is crucial to reducing barriers for development.*
10. *State and Federal Governments should more directly link local community employment, training, economic and social programmes to unconventional gas taxation receipts. New governance frameworks could be developed to enable economic and social benefits to be optimized for specific impacts under both State and Federal funding disbursements.*

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Chapter 1: Introduction

The world is increasingly taking interest in the potential for a shale gas revolution. Australia is no exception to this trend. The key question for Federal, State and local governments is, assuming a shale gas revolution is seen as desirable, what policy measures may be taken in order to achieve this end and what should any debate over shale gas policy be focusing on? This brief paper sets the context for any shale gas revolution. It then outlines the characteristics present in the US that were necessary for the generation of its shale gas revolution. In the context of Australia, there are many barriers to reproducing these characteristics. This paper considers what policy options are available to reduce such barriers and lead Australia to its own shale revolution.



Chapter 2: The “Shale gas revolution” in the US

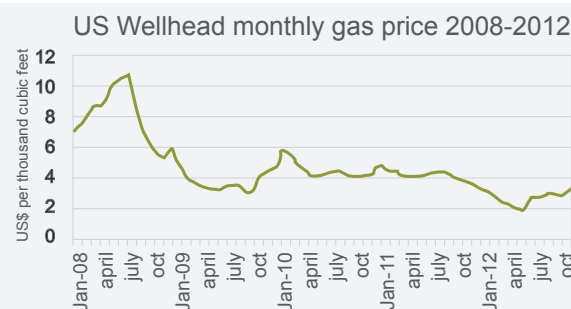
A brief history

The shale revolution in the US is based on the application of two main technologies – horizontal drilling and hydraulic fracturing (fracking). Neither is new technology. Horizontal drilling was developed in the 1930s and the first well was fracked in the US in 1947. The revolution has been reflected in the dramatic increase in the production of shale gas. In 2000, shale accounted for less than 1 per cent of US domestic gas production. In 2007 it was 8 per cent and only four years later, in 2011, it was 30 per cent. However, a key point is that this American “revolution” in reality happened over a long period of time – more than 20 years, although it is only in the last five years or so that the share of shale gas in domestic production has increased significantly. Furthermore, this growing role of shale gas is expected to continue. The Energy Information Administration (EIA) suggests shale gas will supply 42 per cent of domestic US gas production by 2040 and another source puts shale at more than 50 per cent by the 2030s [1].

The impact in the US

The impact of this shale gas revolution has been significant¹. The most obvious impact has been on US domestic gas prices, as can be seen from Figure 1.

Figure 1



Source: US Energy Information Administration.

This dramatic fall in gas prices has had several important effects. It has led to a significant revival in US petrochemical and other gas intensive manufacturing industries. It has also pushed coal out of much of the electricity generation, leading to increased coal exports and a reduction in the US’s carbon footprint. Internationally, it has had a significant impact on the global LNG trade. Between 2005 and 2009, 75 per cent of US LNG regasification capacity was built in anticipation of falling domestic US gas supplies. By 2011, 90 per cent of total capacity was idle. At the same time, LNG export plants which had been built in anticipation of greater US demand, suddenly found themselves scrambling for alternative markets. The result was a potential oversupply of LNG leading to downward pressure on prices².

¹ Not least in the development of a dramatic increase in hydrocarbon liquids production. According to the BP Statistical Review of World Energy for 2013, 2012 saw the largest annual increase in liquids production in the US since the industry began in 1859. This, however, is not covered in this paper.

² This was temporarily relieved as a result of the Fukushima nuclear accident that forced Japan into the LNG spot market.

Why it happened in the US

A key question that is relevant to the Australian story is why this shale gas revolution happened in the US? The answer lies in the coincidence of a number of characteristics. To understand what these characteristics were will provide a guide to help understand what may be needed in Australia if the US experience is to be replicated. They are listed in Table 1 below.

Table 1: Factors creating the 'shale gas revolution' in the United States

1. GEOLOGY
1. Large shallow, material plays, implying large technically recoverable resources. Also much of the shale had low clay content, making it easier to fracture.
2. After many years of oil and gas drilling, there was plenty of drill core data publicly available to allow explorers to find the 'sweet spots' on the plays.
3. Although not in the early days in the Barnett and the Haynesville, the shale gas in later plays had a high liquids content, which greatly enhanced the economics of the operations, especially at a time when gas prices were low.
2. RESEARCH
1. In 1982 the US government began extensive funding of R&D by the Gas Technology Institute into 'low permeability hydrocarbon bearing formations'. The results were widely disseminated to the industry.
3. REGULATION
1. The Energy Act 2005 explicitly excluded hydraulic fracturing from the Environmental Protection Agency's Clean Water Act – the so-called 'Cheney-Halliburton Loophole'. Thus, much of the US shale gas operations were done with little or no environmental impact assessments.
2. The 1980 Energy Act gave tax credits amounting to 50 cents per million British thermal units (BTUs). It also introduced the Intangible Drilling Cost Expensing Rule, which covered (typically) more than 70 per cent of the well development costs, crucial for small firms with a limited cash flow. These economic incentives were very important in the early stages of the industry, which was based on small, relatively cash strapped, entrepreneurial companies..
3. Property rights in the United States make the shale gas the property of the landowner, creating a strong financial incentive for private owners to allow the disruptions associated with shale operations. Also, the population is used to being in proximity to oil and gas operations.
4. The system is used to licensing large areas for exploration with fairly vague work programme commitments, which is what is needed when dealing with shale plays.
4. THE NATURE OF THE GAS MARKET
1. Pipeline access is based on 'common carriage', so gas producers at worst have at least some access to existing pipelines, transforming the economics of shale gas production. The US also has a very large and extensive gas pipeline grid to move gas around the country.
2. The US is a 'commodity supply gas market', i.e. a lot of buyers and sellers and good price transparency. Gas is easy to sell.
3. The US domestic gas market experienced strong rising prices in the period after 2002, culminating in a price over \$10 per thousand cubic feet (mcf) in May 2008.
5. INDUSTRY
1. The industry was dominated by small, entrepreneurial companies, the so-called 'momma and poppa' companies.
2. The majority of the work was done by a dynamic, highly competitive service industry. At the height of operations in the Barnett Play in 2008, 199 rigs were operating.



Taken together, the characteristics listed in Table 1 explain why the shale gas revolution began in the US. To a large extent their relative importance depends on the sequence. The story starts with the fact of favourable geology, plus large amounts spent on R&D by the government. Then tax credits and drilling cost expensing started the actual operations, which were able to operate in a broadly supportive regulatory regime, especially given the 2005 exclusion of fracking from the EPA's Clean Water Act. This was in regions for the most part used to oil and gas operations, incentivized by the property rights and assisted by a dynamic and competitive service industry to drill and to hydraulically fracture. The gas market, both in terms of trading and transport, contributed; as did the high liquids content of the gas in later plays at a time when low prices might have been expected to slow developments. All this implies that some combination of these characteristics is required if the US experience is to be replicated elsewhere.

Chapter 3: The prospects in Australia



The need for gas

The picture for conventional gas is given below in Table 2. Currently, Australia is in the process of building seven LNG plants, in addition to the three already operating. Other LNG projects are in the pipeline, but given the cost inflation of LNG projects it seems unlikely they will get off the drawing board in the near future. All this is with a view to exporting some 4.24 trillion cubic feet (tcf) or 120 billion cubic metres (bcm) by 2035, compared to 0.88 tcf (25 bcm) in 2010, although by 2016, 1.77 tcf (50 bcm) is expected.

Table 2 Conventional gas in Australia

	2002	2012
Proven reserves of conventional gas (tcf)	87.5	132.8
Reserves to production ratio (years)	74.0	76.6
Production billion cubic feet per day (bcfd)	3.2	4.7
Domestic Consumption (bcfd)	2.2	2.5
Exports (bcfd)	1.0	2.2

Source: BP Statistical Review of World Energy 2013

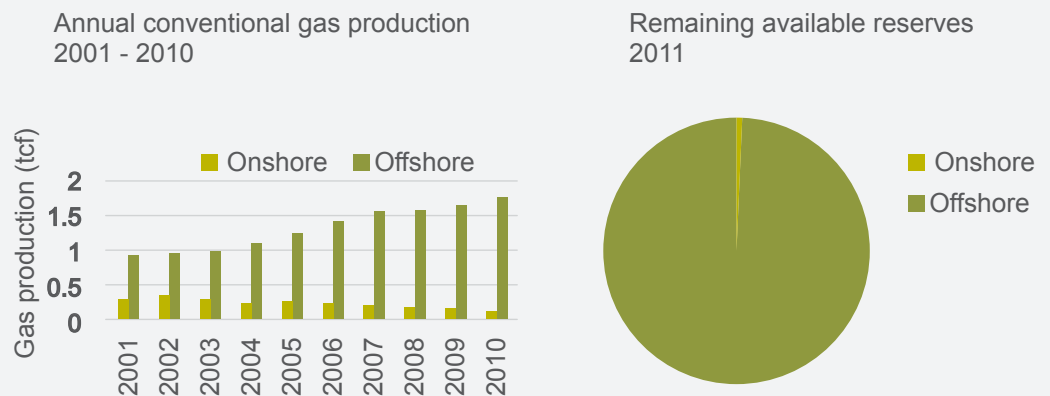
Whatever the numbers, there is already growing concern that Australia will not have sufficient gas to meet LNG plants plus growing domestic consumption. This has been reinforced by the government implementing policies to encourage greater use of gas for climate change reasons. Competition between the domestic and international gas demand exists, as gas producers prefer to exploit the gap between domestic and international LNG supply, made possible by the former Australian Labor Government policy prioritising exports over domestic supply. The new Australian conservative government of Prime Minister Tony Abbott seems to support a similar policy, but since winning the election on 7 September, 2013, has made it clear it will have its own Energy White Paper within a year.

Domestic gas prices could be in the order of A\$2.83 per thousand cubic feet of gas [2]. With gas producers favouring exports, domestic gas prices may experience upward pressure. Manufacturing industries reliant on gas as the predominant energy source are struggling to secure long-term contracts, due to the rapidly increasing LNG exports causing price insecurity in domestic gas supply. Therefore, the domestic gas price is projected to increase to \$7-\$10 within the next three years in both the east and west coast markets, thereby reaching parity with the export price level [3]. The manufacturing sector argues this will lead to a reduction in their competitiveness, leading to job losses. There are now calls for a moratorium on future LNG projects. Furthermore, this has given rise to a debate over whether the Australian Government should introduce a 'reservation policy' for the east coast gas market. The idea is, through some legislative intervention, a proportion of production will be held back for domestic use rather than export. The suggestion is controversial and the petroleum industry argues it is policy interference in the market's natural performance. Clearly a lot of gas will be needed in either scenario. The IEA's Golden Age of Gas Report predicts that gas production will have to rise from 1.59 tcf (45 bcm) in 2008 to 2.97 tcf (84 bcm) by 2015 and 4.45 tcf (126

3

bcm) by 2020 [4]. Of this, in 2008 some 10 per cent came from unconventional gas, however this will need to rise to 45 per cent by 2035, the majority being made up of coal bed methane. However, Australian LNG exports to the Asian market may have to compete with the LNG exports from North America, Qatar and East Africa beyond 2018 with growing natural gas developments [5]. It should also be remembered that most conventional gas resources in Australia are offshore (Figure 2), more expensive to develop and far from regional markets, despite as-yet-unproven ships being built with LNG processing plants (FLNG). This suggests that increased shale gas production could play a valuable role in Australia's energy future.

Figure 2



Source: Geoscience Australia

The potential resources

Australia clearly has shale gas resources. In April 2011, the US's Energy Information Administration (EIA) estimated Australia's technically recoverable resources at 396 tcf based on an assessment of four basins. These are divided between the Canning (229 tcf), the Cooper (85 tcf), the Perth (59 tcf), and the Maryborough basins (23 tcf). In its latest Energy Outlook of June 2013, the estimate had increased to 437 tcf. Geoscience Australia gives a figure of 388 tcf. These figures compare with estimates of recoverable proven reserves of conventional gas from Table 2 of 132.8 tcf, although it is important to remember that technically recoverable resources are very different from proven reserves. In the US, the rule of thumb used is that, of the technically recoverable resources, some 10 per cent are likely to be produced. At some 40 tcf this is still a significant asset.

3

Developments so far

The first exploratory vertical (Holdfast -1) and horizontal (Holdfast -2) wells aimed at shale gas were drilled in 2010 and 2013 by Beach Energy in the Cooper Basin, South Australia. The first commercial shale gas development was initiated in 2012 by Santos with the Moomba-191 vertical shale well. The initial well flow rates ranged from 1.000 million cubic feet per day (mmcf/d) to 2.600 mmcf/d [6]. These rates are in line with the successful North American shale development rates [7]. DrillSearch Energy and Senex Energy are also operating on Cooper Basin shales. The Cooper Basin shale play is projected to grow up to 70 wells by 2015 and up to 2500 wells in total by 2028, recovering some 6.0 tcf [8]. This is mainly due to the Cooper Basin being the most productive area to conduct shale gas development because of existing pipeline infrastructure and processing facilities. However, even in the Cooper Basin there are no paved access roads after 50 years of operation. The other basins around Australia have also shown increasing activity in terms of exploration and seismic studies. AWE operating in the Perth Basin, Western Australia, has reported shale well production rates around 0.35 mmcf/d [9]. Local companies have partnered with international companies to gain access to the capital, technology and skilled personnel required for shale gas operations. In the Canning Basin, PetroChina, Conocophilips, BG, Hess and Mitsubishi are operating alongside local companies Buru Energy and New Standard Energy. Chevron and BG are operating alongside Beach Energy and others in the Cooper Basin, while Central Petroleum, Stat Oil, Armour Energy, PetroFrontier, Blue Energy and Australian Oil and Gas are operating on the shale gas assets of Georgina basin in the Northern Territory. However, Australian shale wells are yet to be fully tested with horizontal drilling and fracturing.

Chapter 4: The challenges to developing shale gas in Australia

In May 2013, University College London ran an executive training programme on *The Shale Gas Revolution and Australia: Threats and Opportunities* in Adelaide. During the programme, participants, all of whom were involved in Australian gas operations in various forms, were asked to rate what they saw as the key barriers to the development of shale in Australia, based on the factors listed in Table 1. Four key challenges emerged³. The respondents saw the main barrier as the lack of favorable geology. The three other top barriers were seen as the lack of a dynamic and competitive service industry, access to pipelines and the environmental lobby. This view is also supported by findings of our own ongoing research on shale gas developments and comparisons with the US shale gas industry. The four challenges are described in the following sections.

Geology

The Cooper Basin, South Australia has the most developed infrastructure, but, being Lacustrine (“of a lake”), rather than marine (“of a sea”), in origin, it is not a conventional shale play. It is known as a “basin centred” gas play, since the formations are siltstone rather than real shale, similar to the Barnett shale play in Texas [10]. Formations are also deeper and have higher clay and CO₂ contents. This will lead to a reduction in the CH₄ content of the produced gas, leading to lower economic benefits. Therefore, the effectiveness of using similar technology to develop shale gas resources in Australia is questionable, with no guarantee of long-term success. Australian shale plays are also subjected to higher tectonic stresses compared to North American shale plays. Therefore, Australian shale gas success will be mainly based on finding the best formations with liquid content to get the maximum economies of scale. Higher liquid content will provide the funding necessary for the infrastructure required to initiate the shale gas production in these isolated basins. However, currently there is no prioritising of shale gas projects based on the best basins, mainly due to a lack in seismic data (2D and 3D) required to verify more lucrative areas for shale gas production. The estimated ultimate recovery (EUR) is a useful guide to understanding the resource potential of a shale gas well. As illustrated in Table 3, Australian shale plays have shown a similar resource richness compared to US shales. For US shales, resource richness over 2.0 billion cubic feet (bcf)/km² often led to higher EUR.

³ Of course this can hardly be described as a “scientific sample” but at least it provides some insights as to what the perceived barriers might be.

Table 3: Resource richness of US shale plays and Australian shale plays

Shale play	Recoverable gas resource (bcf/km ²)	Estimated ultimate recovery (bcf/well)
US shale plays		
Barnett	2.59	1.42
Barnett Woodford	4.61	3.07
Cana Woodford	3.20	5.20
Eagle Ford	7.37	5.00
Fayetteville	1.37	2.07
Haynesville	3.21	3.57
Lewis	0.60	1.30
Mancos	1.23	1.00
Marcellus	1.67	1.18
Woodford	1.82	2.98
Australian shale plays		
Amadeus	2.19	N/A
Beetaloo	2.62	N/A
Bonaparte	1.60	N/A
Bowen	1.89	N/A
Canning	2.48	N/A
Cooper	3.79	N/A
Georgina	2.91	N/A
Maryborough	2.33	N/A
Mcarthur	2.91	N/A
Otway	2.19	N/A
Perth	1.17	N/A

Source: ACOLA Report (2013), EIA Report (2011)

4

Service industry

Currently, the extent of the service industry in terms of drilling and hydro fracturing services in Australia is not adequate. The US shale gas success was mainly based on the advancements in multi-stage fracturing and horizontal drilling. The US has more than 1700 drilling rigs in operation, of which more than 60 per cent are horizontal drilling rigs [11]. However, in Australia there are only a handful of drilling rigs that can access depths in excess of 3000m, inhibiting the prospects of shale gas development immensely. Currently, there is only one permanent drilling rig operating at the Canning Basin and in the Cooper Basin only three drilling rigs are operating on shale developments. The cost of moving drilling rigs is also substantial. Currently, only a limited number of service companies are offering hydraulic fracturing services; namely, Halliburton, Baker Hughes and Schlumberger. However, shale gas development requires rapid well replacement procedures and many wells to be fraced simultaneously. Therefore, these service companies must expand their capacity substantially to enable growth of the shale gas industry, or new entrants must be attracted to the market. In a global context, Australian fracing capacity is less than 1 per cent [12].

Fracing fluid is comprised mostly of water (at least 95 per cent); ‘proppants’ (to keep fractures propped open allowing trapped oil and gas to escape) and a small percentage of chemicals (less than 0.5 per cent). The proppant is usually sand or manufactured ceramic balls, the latter is more suited to deep shale in order to withstand the considerable crushing pressures. The chemicals used, some of which are found in commonly used household products, are required to carry the proppant (guar gum), remove bacteria (glutaraldehyde), prevent corrosion (methanol), restrict scale formation (hydrochloric acid) and reduce friction (polyacrylamide) to enable easier pumping of frac fluid and sand into the well.

The amount of water used (and produced) in the fracing of shale formations is substantially less than in coal seam gas (CSG) extraction. In the latter, water must be removed from the coal seams to reduce pressure and release any gas present. In contrast, the very deep shale formations are far removed from groundwater aquifers and, hence, do not need to be dewatered. Such rock formations typically require 10-20 ML of water per well for fracing, with 0.04-0.4ML of water required per frac stage. A horizontal well may require up to 15 fracing stages. However, that said, wherever fracing takes place, the water that flows back from the wells after fracing must be collected and, ideally, treated and recycled or, at least, disposed of under highly policed environmental practices, including lined pits or tanks. In Australia’s remote gas-rich basins, while proper disposal practices are being carried out, there are currently, at this early stage of the shale gas industry, few recycling facilities. Hence, there is a shortfall in the services for shale gas exploration and production necessary if the industry is to expand in the same way as occurred in the US. The slow growth of shale gas developments is also affecting the attraction of new service companies to the market.

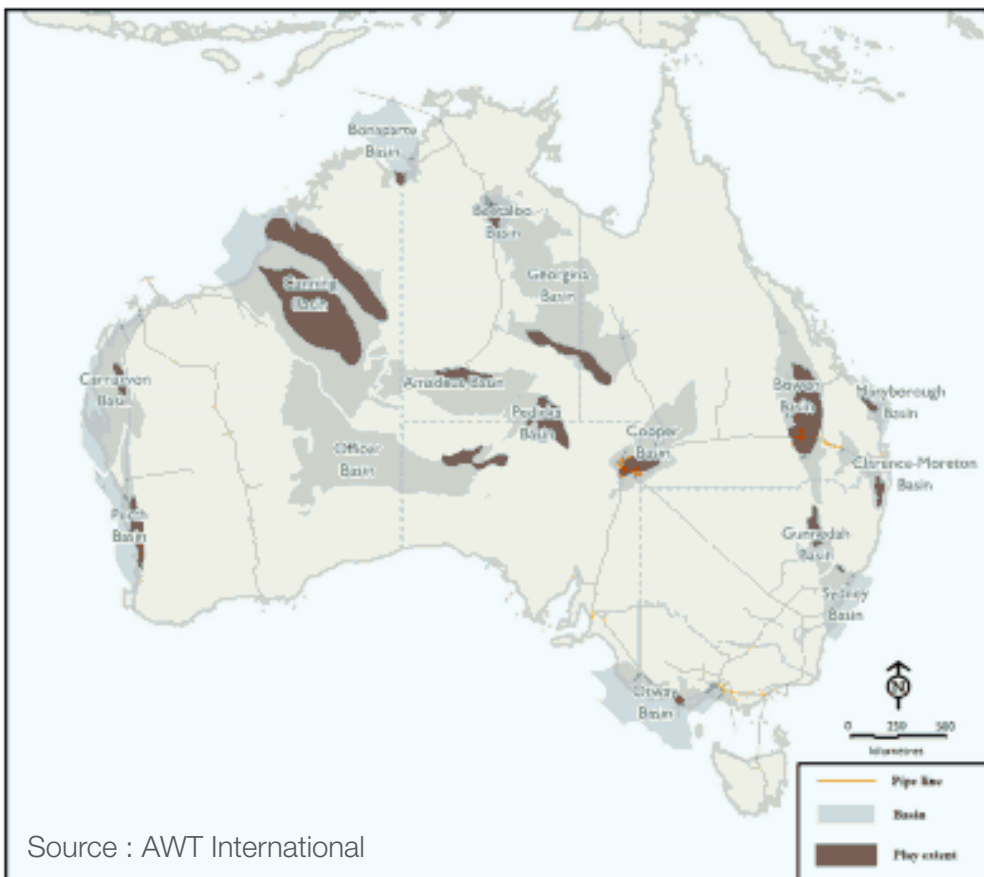
The lack of skilled personnel is also contributing to increased costs. Currently, shale gas drilling and fracing are more than three times as costly as in the US [13]. In addition, the ceramic proppants and guar gum required for deep shale well fracturing are currently not manufactured in Australia and, hence, must be imported from overseas, mainly from China and India. For a typical single horizontal well, fracing can use anywhere from 1,000 – 10,000 metric tonnes of proppant and about 10 metric tonnes of guar gum, so if the shale gas industry is to expand and this situation continues, then the import volumes would be considerable.

Unlocking shale potential is predominantly based on the enhancement of technologies. Acquiring and fine tuning current technologies are important for Australian shales. Current technologies have mostly been practiced and perfected on North American shales and these technologies need to be customised for Australian shale development. The expansion of the service industry is vital to effectively engage in this development.

Pipeline access

Domestic pipeline transport is the most effective means of transporting gas directly to either consumers or towards an LNG terminal without any processing. Figure 3 shows the potential Australian shale plays, along with the existing pipeline infrastructure. While the infrastructure in the Cooper Basin is reasonably good, there are no pipelines connecting the Canning, Georgina, Pedrika and Officer basins to the existing main transmission lines. This is a substantial barrier to shale gas development in these regions.

Figure 3



Source : AWT International

Access is also constrained by the current regulation regime for pipelines. Most of the Australian gas pipelines are regulated through contracted carriage. Therefore, access is restricted for new entrants to the markets, as there are only a limited number of natural gas transmission pipelines that have been regulated allowing full third party access. The Australian Energy Regulator is the regulation authority for pipeline access in Australia, except for Western Australia, where it is the Economic Regulation Authority. To date, only six out of 14 major eastern gas transmission lines, two out of eight major western gas transmission lines and 10 distribution networks are fully regulated for third party access [14]. The Australian natural gas pipelines are privately owned and usually operated under long-term contracts.

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Although this long term association is vital to ensure the recovery of pipeline investment costs, it deprives access to new entrants. Currently, the natural gas pipelines are not utilized to the optimum level, especially with seasonal temperature variations [14]. However, for unregulated pipelines, it is at the discretion of already contracted companies to decide on subcontracting of any unused pipeline capacity. Thus, contract carriage is a barrier to third party access.

Environmental lobby

Environmental concerns on hydraulic fracturing have to be addressed to increase the confidence on shale gas projects. In Australia, community concerns over both fracking and de-watering have arisen from increased shallow CSG activity on agricultural land in QLD and NSW in recent years. However, as mentioned above, fracking of shale gas formations is largely a different process. In South Australia, much work is being done to raise awareness of these differences and to work with communities to minimize any potential negative environmental impacts. All South Australian oil, gas and geothermal activities are regulated under the South Australian Petroleum and Geothermal Energy Act 2000 [15] and the Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) employs a range of technical experts, including drilling engineers, to ensure the necessary approval conditions are in place and procedures are strictly adhered to. The composition of the fracking fluids must be reported and risk assessments carried out to ensure that there is no risk of contaminating aquifers as a result of fracking.

There are some misunderstandings in the community surrounding earthquakes and fracking. Although it is true that fracking operations may cause minor seismic activity, these events are rarely even detected by people on the surface. Furthermore, greenhouse gas emissions could arise from flow backs and from the drilling and fracking processes. Therefore, operators and regulators need to be proactive in order to effectively engage with these community concerns. More government funded research needs to be conducted to verify these effects and recommend good practice. There are examples of good practice, especially in South Australia, which could be replicated elsewhere. The implementation of transparent mechanisms disclosing the types of chemicals used during the fracking process and the adherence to well-defined regulatory procedures of well construction are important steps to winning community confidence.

Industry requires both a regulatory licence and a social licence to explore and produce. In the light of the impending shale gas revolution, new governance approaches need consideration.

In the current context, these four issues – poor geology, lack of a service industry, pipeline access and environmental concerns – can be seen as the key ones to be addressed if there is to be a shale gas revolution in Australia. However, other issues also emerged from the UCL Australia survey, including fracking regulations, property rights, licensing restrictions and lack of investment on research and development. As a result, as things stand, Australian shale gas developments may not replicate the experience of the US without policy and regulatory measures. However, given the resource base, shale gas has the potential to become an important energy resource in Australia. Therefore, policy solutions need to be developed to address the issues identified here.

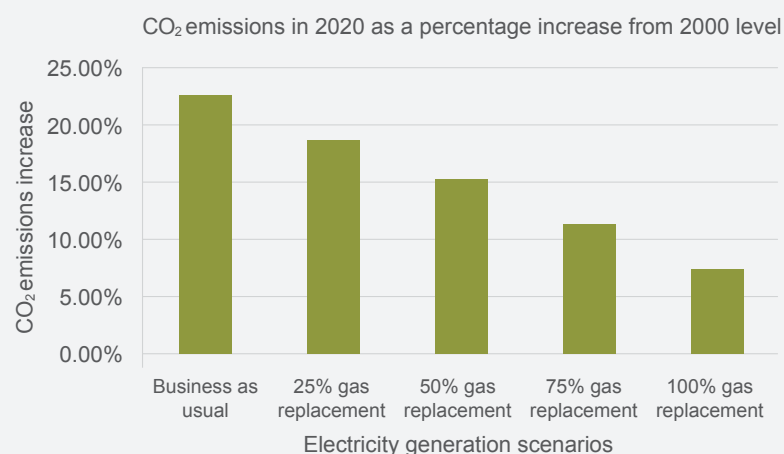
Chapter 5: Policy recommendations



For policy makers there is a distinct “trilemma” of managing energy security and creating steady economic growth⁴, while at the same time addressing climate change concerns. This requires a combined effort from the industry, state and territory governments and the Australian Government. Policies must be developed to ensure that those energy resources with a low greenhouse gas impact, such as renewables and natural gas, are prioritized. However, currently there is no policy for prioritizing energy resources based on their contribution towards base load power for industrial and residential requirements. Such a policy needs to specify the role of different energy resources to be utilized in catering for the domestic energy demand. Although there is much discussion regarding a transition towards renewable energies, there is insufficient capacity to fulfill base load energy demand with renewable energies in the immediate future. Therefore, the fossil fuel resources cannot be written off, at least not for the next two decades. Natural gas emits only about 50 per cent of greenhouse gas emissions when combusted, compared to coal. Therefore, due to its availability, and all other things being equal, natural gas can be viewed as the optimal energy resource in the transition to a low carbon future.

The national greenhouse gas emission target for 2020 is to reduce emissions by 5 per cent of the levels in 2000 [16]. This will not be achievable unless more gas is used for base load power generation. Gas based electricity generation not only reduces CO₂ emissions by 50 per cent, but also reduces SO₂ emissions by 99 per cent, NO_x emissions by 80 per cent and particulate emissions and mercury emissions almost by 100 per cent [17]. In 2000, CO₂ emissions based on stationary sources were estimated to be around 175 Mt out of a total of 565 Mt [18]. If gas-based power replaces coal-based electricity generation, this would contribute significantly to achieving the stated CO₂ emission target. Figure 4 illustrates the importance of natural gas in reducing greenhouse gas emissions from electricity generation. However, the target cannot be achieved solely by switching to gas-fired power generation. Energy efficiency improvements and the use of renewable energy sources will also be necessary.

Figure 4



Source: Department of Climate Change and Energy Efficiency

⁴ There is a debate growing over whether Australia (which is facing the prospect of an attack of “resource curse”, whereby a dominant natural resource sector causes damage to other sectors of the economy, for example, as a result of exchange rate over-valuation) should be further developing its natural resources. This is an important debate, but is not covered in this report.



Another factor to take into account is that the Australian manufacturing industry is facing severe natural gas shortages caused by the increasing commitments of gas suppliers to LNG contracts. This is leading to price spikes as manufacturers come to renew their long-term gas supply agreements [19]. The call in some quarters for a reservation policy for the east coast gas market is controversial and regarded by many as an inefficient policy. A more effective policy might be to align local manufacturing companies, either individually or as an alliance, with the local shale gas operators. However, major shale gas operators with the luxury of contingency resources would not find this attractive, as they would prefer international LNG contracts with higher returns. It would be of more interest to smaller scale operators as they look to de-risk their projects with much needed capital. Such efforts would not only help the shale gas industry to prosper, but could also secure much needed long term gas supplies to the manufacturing industry. A good example is where Orica, a major Australian explosive and commercial blasting company, invested in coal seam gas in the southern Cooper Basin with Strike Energy, based on a long-term gas supply contract of 0.15 tcf over 20 years⁵ [20]. In the US, shale gas has provided a much needed recovery in the manufacturing industry, with the availability of lower priced gas, leading to cheaper products and greater competitiveness in overseas markets. It is claimed that dedicated gas supply for manufacturing industries in Australia could save about 200,000 manufacturing jobs [21].

The human capital and skills level for the shale gas industry itself also needs to be developed. Currently, only South Australia has proposed a 'planned development approach' for shale gas, DMITRE publishing the "Roadmap for Unconventional Gas Projects in South Australia", which provides a comprehensive plan to expand the industry to recover about 6.0 tcf of gas by 2028 [8]. Queensland is about to embark on a similar exercise. By comparing the number of required wells for this expansion with the US experience it can be estimated that, for South Australian shale gas developments, more than 17,500 jobs could be created (62 jobs per well) [8, 22]. Based on these estimates, similar shale gas developments in the other states – particularly Western Australia and Queensland – could create up to 100,000 jobs nationally. Additionally, there will be more short term employment opportunities created in a growing gas industry.

Geology

Obviously, geology cannot be changed by policy. However good policy can affect the commerciality of the geology.

The first option is to improve the fiscal terms given the government, as the owner of the sub-soil gas, determines the fiscal system under which companies operate. This was an important factor in the US story of shale gas in the early days, with the tax breaks for unconventional operations in the Energy Act 1980, in place until 2002. More recently, the UK Government has offered what it views as attractive fiscal incentives to shale gas operations in the hope of kick-starting the industry. The new proposed system acknowledges that there is a slower cost of recovery for shale gas

⁵ The contracted gas price is estimated to be around A\$3 - A\$7 per mcf.

projects compared to conventional offshore developments and that costs are often spread over a much wider area than a traditional oil or gas field⁶. In Australia, the new Australian Government has announced an exploration development incentive scheme will be implemented from July 2014 to increase mineral exploration activities. This scheme will enable investors to deduct mineral exploration expenses against their own taxable incomes [23].

Another policy contribution for government to improve the commerciality of the geology would be to fund basic scientific research relating to shale gas operations, again following the government of the US. The sort of research envisaged is into fundamental science. Scientific research has certain characteristics that make it a “public good”⁷ and, hence, should not be carried out by private companies. No private company would fund Isaac Newton to sit under his apple tree in order to “discover” gravity. Although gravity is a key scientific building block at the centre of Western science it has no commercial value and, indeed, once “discovered”, cannot be patented to allow the funder to recover their financial outlay. For example, when ExxonMobil withdrew from Poland in March 2012, the CEO explained that the technology used so successfully in the US was simply not working on the Polish geology. He went on to say that much more research was needed to make the technology work. Potentially, this remains a serious barrier to developing shale gas in Europe. One promising sign of this in Australia was that late in 2011, the Australian Government established an expert scientific committee to examine water-related impacts from coal bed methane, funded with A\$150m over four years. Certainly Australia has the scientific capabilities to undertake such scientific research.

Shale gas service industry

The Australian shale gas industry has the potential to grow in a similar manner to the industry in the US. However, as discussed in Chapter 4, there are an insufficient number of companies able to service this expansion, with only a handful currently involved in shale gas operations. Innovative policies are required to attract more service companies into the market. It would be possible to encourage the development of a service industry for drilling and fracking by offering a more attractive tax regime, possibly by altering capital allowances and depreciation terms to such companies. Domestic production of fracking materials could also be encouraged.

The US shale gas revolution benefitted from operators and service companies working together as an alliance, sharing infrastructure and vital technological enhancements. This has decreased the cost of developments significantly. Pad drilling, improved fracking mechanisms and improved rig mobility are such developments, leading to increased efficiency and growth [24]. As a result, though the number of operating rigs is reducing, the number of wells fraced is significantly

⁶ The UK government proposed the following two tax incentives to cover these concerns. First, the so-called “pad allowance”, which is tax on a proportion of income generated from producing shale gas that will be reduced from 62 per cent to 30 per cent for the lifetime of the shale well. Second, the “Ring Fence Expenditure Supplement” for shale gas projects will be extended from six to 10 accounting periods.

⁷ Public goods are goods or services whose consumption is non-rival and where exclusion from using it is not feasible. Non-rival consumption means there is no supply curve and non-exclusion means there is no demand curve. Absent supply and demand curves mean that there can be no price and therefore the private market cannot effectively allocate resources to produce the good. Conventionally, the government allocating resources to the production of the good or service solves this problem.



rising [25]. There is also an influx of horizontal well rigs replacing vertical drill rigs. Simultaneously, the drilling and completion costs have also reduced by more than 30 per cent [25]. Information sharing is key for new entrants to the market, as they will become more efficient more quickly. As an example, in the US the Marcellus shale coalition consists of 300 partnering operators and service companies and has led to an exponential increase in production within a shorter time span. It has also helped to push the industry up the technological learning curve at a faster rate.

Australian shale gas operators would mutually benefit working together as an alliance. However, the number of operators in Australian shale basins is far fewer compared to the US. Currently, only about 20 shale gas companies are operating in the six identified Australian shale basins within an area in excess of 900,000 km². In the Marcellus shale play alone there are more than 90 operators within a 10,000 km² area [26]. There is a significant participation of smaller scale independent operators, rather than the major operators.

Comparatively, the leased acreage area is significantly higher in Australia than in the US. Hence, existing leased acreage permits could also become a significant barrier to attracting new operators into the market. Some basins are leased to only a handful of operators, with activity at a very low level, particularly in the Canning Basin. This is not beneficial for the current operators, given that they will have to bear the cost of infrastructure individually. New Standard Energy, operating in the Canning Basin, has had to construct two airstrips and a 500 km access road costing more than A\$10 million, just to provide access to two exploration wells [27]. Furthermore, processing facilities and pipelines for transportation during the production phase will also be required. Such costs are significantly affecting the company's share price and, hence, its ability to expand. Collective funding of such important infrastructure would lower the capital cost burden on the small number of operators. More participation would expedite the development process. Therefore, government intervention is critical to relinquish land where original work programmes are not being adhered to and to release smaller plots to encourage new entrants to the industry. New Federal Industry Minister Ian Macfarlane has threatened to revoke retention rights of operators who shelve their projects ("use it or lose it") [28]. This is an important signal to off and onshore gas projects. Similarly, governments might also be in a position to encourage cooperation between companies by a helpful interpretation of competition policy.

It is worth pointing out that given the growing interest in shale gas in Asia more widely, the development of a shale gas service industry of any scale would potentially also be a major export earner for Australia in the years to come. While it is true that the major service companies, almost entirely American, are already involved in Asia, the prospect of competition from other companies would be most welcome by Asian customers. The classic example of this was the Norwegian decision in the early 1970s to use the discovery of North Sea oil to develop a world class Norwegian oil service industry.

Pipeline access

A key part of the shale gas story in the US was the ease with which gas producers could get access to gas markets, both in terms of transportation and in terms of negotiating sales contracts. For transport this is because access to the very comprehensive gas grid is based on common carriage. Thus, even if the local pipeline is full to capacity, a gas producer can still gain access to some proportion of the capacity as other users must reduce throughput on a pro rata basis. In Europe, by contrast, access is by third party access. If the pipeline is full, no access is possible. In addition, in terms of trading gas, the US is a commodity supply market. Thus, there are a large number of buyers and sellers and there is clear transparency on price. This is in contrast to a project supply market, where there are few buyers and sellers and there is limited price transparency.

Both the transportation and trading of gas are directly subject to government regulation. A good example of what can be achieved using regulation as a lever to ensure access is the oil pipeline networks in the UK North Sea. There, access is based on third party access. If the pipeline owner claims the line is at full capacity, there can be no access. Early in the 1990s the UK government made it clear to the pipeline owners that they were determined to maximize recovery of oil from the North Sea. This required them to do all they could to allow access for new developments and not to try and restrict access “unreasonably”. It was made clear that failure to do so would result in the use of legislation, much of which was already in existence, to force access and penalize those creating barriers to entry. This proved sufficient to ensure access.

The Australian gas market was deregulated in 1997 and liberalized to enable third party access and thereby increase competitiveness [29]. However, although the specific objective of the Australian National Gas Act is “to promote efficient investment in, and efficient operation and use of, natural gas services for the long-term interests of consumers of natural gas with respect to price, quality, safety, reliability and security of supply of natural gas”, there is no guaranteed pipeline access for new entrants to the market [30]. As with contract carriage there is no obligation to subcontract any unutilized capacity if not fully covered under the regulations for third party access. Thus, the current system does not obligate the pipeline owners to accommodate new entrants or the existing capacity to be shared among the applicants on a pro rata basis. Implementing a common carriage policy and a voluntary pipeline capacity-trading scheme based on the unused pipeline capacities would simplify the access for everyone.

The implementation of a common access policy will help to create a competitive wholesale gas market along the lines of the US experience [31]. However, transferring from contract carriage to common carriage can only be based on demand, since there is only limited opportunity for competition at this stage in terms of emerging shale plays and there is insufficient demand to implement a voluntary trading scheme and a common access policy. Such policies could simplify the gas transactions with enhanced transparency and reliability. Gas transactions could be simplified further by having a uniform tariff structure based on the distance and the quantity of gas shipped. These strategies will encourage new gas developers and retailers to be involved in upstream and downstream gas markets. Thus, increased market competition will not only decrease the bargaining dominance of major producers and retailers, but will also decrease the gas price. All of this enhances the commerciality of shale gas projects.





Environmental concerns

Community acceptance is vital to secure and maintain shale gas operations, given that any moratorium on fracking would restrict shale gas development. It is important to ensure there is an effective and robust regulatory framework in place to mitigate any concerns. Under the existing system the regulatory regime covering upstream oil and gas is shared between Australian, state and territory governments and local authorities. However, while there is an extensive body of regulations, most are not specific to oil and gas and even less so for shale gas operations. Hence, greater transparency and clarity would be aided by a specific regulatory regime for shale gas operations and fracking. While many may argue that the existing regulatory regime is sufficient, this was a key recommendation of the Royal Society/Royal Academy of Engineering (see footnotes 8 and 9). In particular, attention needs to be paid to the quality of well completion and the treatment of waste fracking water. At the very least such a regime, if strictly enforced, would do much to address any concerns of local communities proximate to the shale gas operations. Where there are examples of good practice, for instance, in South Australia, these should be recognized and adopted more widely across Australia. The rapid expansion of CSG operations in some States has created significant public concern over access issues and possible environmental damage, especially in the context of water drawdown, contamination and wastewater disposal. Without proper controls and regulations, this could feed into negative attitudes towards shale gas operations.

At the same time as developing a regulatory regime specifically for shale, the government at all levels needs to develop a credible public relations campaign. Most of the scientific evidence suggests that there need not be any significant environmental impacts associated with fracking⁸, but this is not sufficient to persuade many concerned locals. Already such concerns forced Victoria in August 2012 to introduce a moratorium for fracking for CSG. More research is needed on the extent of fugitive methane emissions that are gathering increased attention as a source of greenhouse gases. Concern on this issue is rising on the agenda and will need to be addressed by research to establish the levels of emissions and possible measures to reduce them if they are at concerning levels.

In addition to regulatory licensing, there is a general understanding that industry needs to obtain a social license to operate. There is also a perceived lack of transparency in relation to strategic planning by governments in the development of unconventional gas resources. Governments may generally have embraced new governance framework approaches, for instance, as with corporate social responsibility. However, there continues to be failures. Without broad community support, it may not be possible to fully exploit the resources.

Ascertaining what is required for community acceptance (rights, evidence, collaboration, duties, monitoring and enforcement) and whether a social contract or other form of understanding is sufficient or whether legislative underpinning is required will be a crucial step in developing appropriate governance frameworks. Consideration needs to be given as to whether present laws are sufficient and, if not, the nature of new models that might be necessary.

⁸ For example see the special report by the Royal Society and the Royal Academy of Engineering in the UK Shale gas extraction in the UK: A review of hydraulic fracturing published in June 2012.

A policy of public disclosure of the chemicals used would help reduce public concerns on hydraulic fracturing. The IEA has actually suggested the disclosure of fracking fluid additives and volumes to be made a mandatory requirement [4]. In the US, Wyoming became the first State to enact such regulation, disclosing the composition of fracking fluids on a well-by-well basis [32]. The well-by-well disclosure is necessary as the companies vary fluid composition depending on the conditions. Subsequently, this has led to voluntary disclosure of fracking fluids. The FracFocus website was launched in 2011 for companies to declare composition of fracking fluids on a voluntary basis for any US well [33]. In Australia, there is no mandatory requirement to publicly disclose composition of the fracking fluids. However, the implementation of such policies leading to increased transparency is key to engage with community concerns.

It is important to convey the message to communities about the economic potential which could flow from shale gas operations and at the same time educate them about shale gas extraction practices. Currently, there are numerous negative messages about shale gas operations, many of which ignore the existing scientific evidence. Shale gas operators could take part in public awareness campaigns to reduce the negative perception on shale gas activities. For example, the EIR report published by Beach Energy (2012) is an effort to demonstrate how their operations minimise impacts on the environment by working within the legislative frameworks [34]. Another, perhaps even more effective step would be to enable universities and research institutes to participate in community engagement, given the large body of scientific evidence in existence on the impacts of fracking⁹. Governments and shale gas operators need to be proactive in reaching out to affected communities to address their concerns and must be accountable and approachable in terms of such concerns. They also must accept responsibility for local community impacts due to shale gas development. There are examples of good practice, but more needs to be done.

Policies leading to increased community engagement and participation will help to promote the confidence in shale gas development projects. Currently, landowners do not have the incentives of ownership of hydrocarbon resources to encourage them to facilitate surface access for shale gas operations. Short of changing the underlying property rights along the lines used in the US, it would be possible to legislate that companies producing shale must “compensate” local communities for the disruption from shale gas operations and include them in the economic benefits of the project. To be fair, many companies are already making serious attempts to do this and there are existing regulatory measures, in relation to oil and gas operations in general, that require companies to provide compensation to landowners. For instance, in Queensland, there is an environmental offset fund to which resource companies must contribute. However, without consistent, specific and transparent regulation and monitoring, such efforts will do little to achieve the desired outcomes.

A good example of such a mechanism is the Shetland Charitable Trust. Initially money came to Shetland by way of the Disturbance Act 1974 to compensate for the disturbances arising as a result of the building and operation of the Sullom Voe Terminal from 1972-74. The funds were initially around £2 million and amounted

⁹ For example see the report in the UK on hydraulic fracturing from the Royal Society and the Royal Academy of Engineers published in June 2012.



to more than £81 million by 2000 when they stopped. Other funds came from a per barrel royalty paid for every barrel loaded at Sullom Voe. At its peak the fund amounted to £250 million, but the valuation has fluctuated significantly over the years as a result of stock market booms and busts. Spending decisions are at the discretion of the trustees and money has been spent on numerous projects, including supporting traditional industries such as agriculture and fisheries, but also projects aimed to improve the quality of life of the population through social need, leisure, environment and education. Money has also been spent on providing care homes and respite centres for the elderly. In an attempt to create something similar to this, the UK Government recently announced a compensation scheme specific to shale gas operations in an attempt to assuage local opposition. Under this scheme, local communities will receive £100,000 per well drilled (although some reports indicate this will be per well site), plus 1 per cent of the revenues.

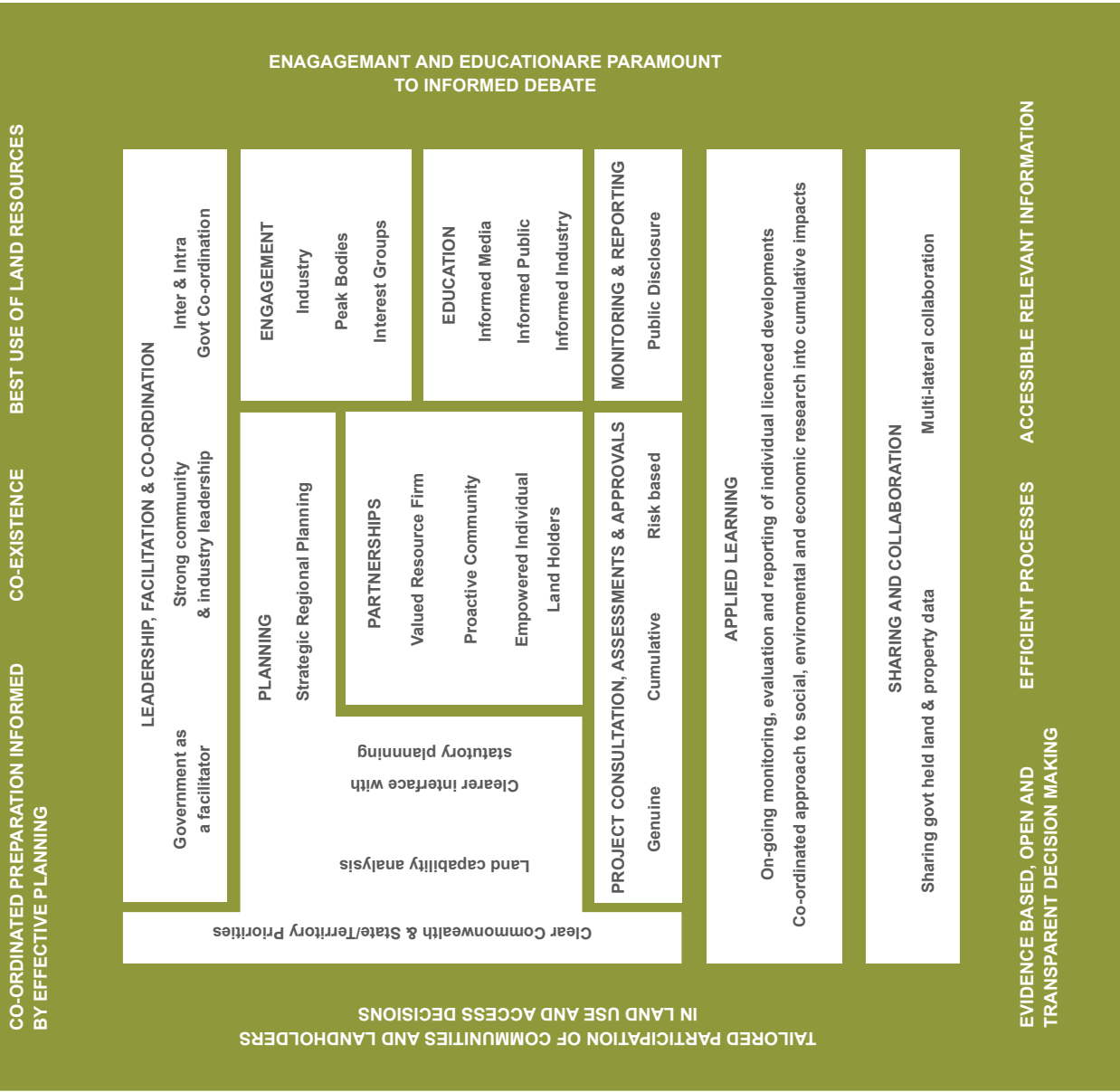
In Australia, the Multiple Land Use Framework (MLUF) is being proposed as a crucial step in overcoming issues arising from investment in resources exploration and development [35]. The MLUF is aimed at achieving four main outcomes:

- a. A shared commitment between the minerals and petroleum sector and regulators on multiple and sequential land uses;
- b. Better informed public discourse;
- c. Merit-based land access decisions; and
- d. Better outcomes for affected communities and land holders.

The MLUF framework includes nine components and eight guiding principles (Figure 5). The components include leadership, planning, partnerships, engagement, education, sharing and collaboration. The guiding principles have to be embodied into the thought process of governments, community and industry in land use planning, policy and development. Thus, it is hoped that the MLUF will provide an effective platform to engage with community concerns on shale gas development. However, full implementation will require universal agreement and adoption by all land users, which may be difficult to achieve in practice.

The MLUF platform recognises the importance of effective collaborative leadership by government, industry and community. Early engagement with stakeholders is also recognised as being crucial. Effective planning, partnerships and education are given a high priority. Transparency, accountability and consistency are to be maintained with assessment and approvals. Applied learning would lead to more informed decisions, with collaboration and data sharing to be encouraged among operators. Simultaneously, the guiding principle of coexistence is aimed at ensuring the rights of land users are respected. However, the integration of a community benefit scheme based on the generated income would have improved the MLUF concept further. Local community incentive schemes based on infrastructure development and employment are crucial to secure social license to operate. Without an obligation, local community development will be at the discretion of the operators.

GUIDING PRINCIPLES



DESIRED FRAMEWORK OUTCOMES

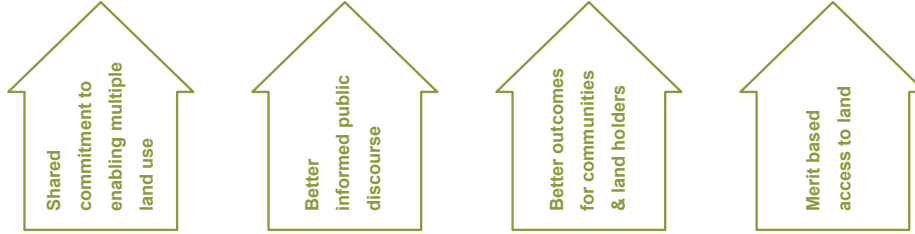


Figure 5

GUIDING PRINCIPLES

Source: Standing Council on Energy and Resources (2013)

Chapter 6: Conclusions

Australia clearly has the potential to make shale gas an important source of energy in the future. However, there are barriers to the creation of a significant shale gas industry if that is what the country desires. The important barriers appear to be limits from the geology, the lack of an adequate service industry, access to existing gas pipelines and markets, and, finally, the need to deal with concerns about the environmental impacts of shale gas operations. All of these barriers can be positively influenced by government policy at State and Territory and Federal levels.

- If Australia wants a shale gas revolution, the commerciality of the geology needs to be improved by making the fiscal systems governing upstream shale gas operations more attractive. This can also be achieved by a concerted effort to make greater use of research and development into the technology of low permeability operations.
- Policy should also encourage the development of a shale gas service industry to drill the wells and hydraulically fracture the structures. Such policies could range from fiscal breaks to the encouragement of greater cooperation among the operators and the service industry. The development of such an industry could prove to be a major benefit to the Australian economy as shale gas interest in Asia grows.
- As for access to pipelines and gas markets, this is very much in the hands of the regulatory authorities. Moving towards the sort of system that underpins the US gas market would be a major step forward that would dramatically improve the commerciality of many shale gas operations. This would involve the greater use of common carriage as the basis for pipeline access and a review of the whole gas contracting system.
- The environmental concerns are all amenable to policy influence. There needs to be a specific regulatory system for shale gas operations, focusing on issues such as well completion, the use of fracking fluids, levels of fugitive methane emissions and the management of waste water. There also needs to be a concerted science-based campaign to counter many of the unfounded claims being made regarding shale gas operations.
- Ascertaining what is required for community acceptance (rights, evidence, collaboration, duties, monitoring and enforcement) and whether a social contract or other form of understanding is sufficient or whether legislative underpinning is required will be a crucial step in developing appropriate governance frameworks for the shale and CSG industries. Consideration needs to be given as to whether present laws are sufficient and, if not, the nature of new models that might be necessary.

References:

- [1] Medlock K B, Jaffe A M & Hartley PR (2011). Shale Gas and U.S. National Security. Baker Institute.
- [2] Morgan Stanley (2012) Australia Oil & Gas , Morgan Stanley Research Asia/Pacific.
- [3] DomGasAlliance (2012) Australia's domestic gas security (http://www.domgas.com.au/pdf/Alliance_reports/DomGas%20Report%202012.pdf).
- [4] IEA (2012) World energy outlook special report on unconventional gas: "Golden rules for a golden age of gas" (http://www.worldenergyoutlook.org/media/weowebiste/2012/goldenrules/weo2012_goldenrulesreport.pdf).
- [5] IEA (2013) Developing a Natural Gas Trading Hub in Asia: Obstacles and Opportunities, International Energy Agency.
- [6] BeachEnergy (2013) Moonta-1 delivered highest gas flow rate to date from Beach's unconventional program (<http://www.beachenergy.com.au/IRM/Company/ShowPage.aspx/PDFs/2806-79589931/Moonta1delivershighestgasflowratetodate>).
- [7] LCI (2011) Lower 48 states shale initial production report. Lippman Consulting Inc.
- [8] DMITRE, SA. (2012), Roadmap for unconventional gas projects in South Australia, Government of South Australia: Energy Resources Division, Department for Manufacturing, Innovation, Trade, Resources and Energy.
- [9] AWE (2013) Arrowsmith -2 flows 350,000 scf/d from Carynginia (<http://www.awexp.com.au/IRM/Company/ShowPage.aspx/PDFs/2783-50678739/Arrowsmith2flows350000scfdfromCarynginia>).
- [10] Cooke D (2012) A brief review of Geoscience issues associated with shale gas development in Australia. University of Adelaide / Australian School of Petroleum, and ZDAC Geophysical Technologies (<http://www.acola.org.au/PDF/SAF06Consultants/Dennis%20Cooke%20GeoScience%20issues%20in%20Shale%20Gas%20Developmen%20Jan2013.pdf>).
- [11] BakerHughes(2013) North America rig count (<http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-reports&other>).
- [12] Robart C (2013) Developing emerging international shale plays. PacWest Consulting Partners. Developing Unconventional Gas Conference, Brisbane, Australia.
- [13] ACOLA (2013) Engineering energy: Unconventional gas production. Australian Council of Learned Academies (<http://www.acola.org.au/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf>).
- [14] SCER (2013) Gas transmission pipeline capacity trading. Standing Council on Energy and Resources Officials (<http://www.scer.gov.au/files/2013/05/Gas-Transmission-Pipeline-Capacity-RIS-Consultation-Paper-May-2013.pdf>).
- [15] Petroleum and Geothermal Energy (South Australia) Act 2000 (<http://www.legislation.sa.gov.au/LZ/C/A/PETROLEUM%20AND%20GEOTHERMAL%20ENERGY%20ACT%202000/CURRENT/2000.60.UN.PDF>).
- [16] National targets 2013 (<http://www.climatechange.gov.au/climate-change/greenhouse-gas-measurement-and-reporting/australias-emissions-projections/national>).
- [17] Smith J (2012) The expanding role of natural gas: Comparing life cycle greenhouse gas emissions, America's Natural Gas Alliance (<http://www.ipieca.org/publication/expanding-role-natural-gas-comparing-life-cycle-greenhouse-gas-emissions>).

- [18] Energy efficiency opportunities and policy update, Department of Resources, Energy and Tourism (<http://www.ret.gov.au/energy/documents/energyefficiencyopps/EEO%20Policy%20Update%20Louise%20Vickery%20-%20Day%20120080626150333.pdf>).
- [19] Manufacturing Australia (2013) Impact of gas shortage on Australian manufacturing (<http://www.gasforjobs.com.au/pdfs/MA-impact-on-jobs.pdf>).
- [20] David W (2013) Southern cooper basin project, Developing Unconventional Gas Conference, Brisbane, Australia.
- [21] Manufacturing Australia calls for government intervention to save 200,000 jobs and an economic value of A\$ 28 billion. (<http://www.manufacturingaustralia.com.au/news/news-releases/new-blogentry-2/>).
- [22] Considine TJ, Watson RW & Considine NB (2011) The economic opportunities of shale energy development. Manhattan Institute for Policy Research. (http://www.manhattan-institute.org/html/eper_09.htm).
- [23] Sacome (2013) Exploration incentive policy excellent news for Australians(http://www.sacome.org.au/images/stories/Exploration_Incentive_Policy.pdf).
- [24] IEA (2012) Pad drilling and rig mobility lead to more efficient drilling. Today in Energy (<http://www.eia.gov>).
- [25] Vincent B (2013) Lessons learned in North America, Developing Unconventional Gas Conference, Brisbane, Australia.
- [26] Hart Energy (2013) Operating companies in Marcellus shale (<http://www.ugcenter.com>).
- [27] Thick, P. (2013) Unlocking our energy future: The potential value of the Canning basin. Developing Unconventional Gas Conference, Brisbane, Australia.
- [28] Macfarlane, I (2013) Use it or lose it, Miners warned by Coalition. The Australian (<http://www.theaustralian.com.au/national-affairs/use-it-or-lose-it-miners-warned-by-coalition/story-fn59niix-1226721368923>).
- [29] Bills digest No.126 1997-98 Gas pipelines access (Commonwealth) bill 1997.
- [30] National gas (South Australia) Act 2008 (<http://www.legislation.sa.gov.au/lz/c/a/national%20gas%20%28south%20australia%29%20act%202008/current/2008.19.un.pdf>).
- [31] Cuddington, J.T., and Wang,Z. (2006). The integration of US natural gas spot markets: Evidence from daily price data. Journal of Regulatory Economics 29(2).
- [32] Hall (2013) Hydraulic fracturing: Trade secrets and the mandatory disclosure of fracturing water composition (<http://www.uidaho.edu/~media/Files/orgs/Law/law-review/2013-symposium/Hydraulic-Fracturing-Trade-Secrets.ashx>).
- [33] Frac Focus Chemical Disclosure Registry (<http://fracfocus.org/>).
- [34] Beach Energy (2012) Environmental impact report. Environmental stimulation of deep shale gas and tight gas targets in the Nappamerri Trough (Cooper basin), South Australia. (<http://www.beachenergy.com.au/IRM/Company/ShowPage.aspx?CategoryId=190&CPID=2937&EID=75598299>).
- [35] SCER (2013) Multiple land use framework. Standing Council on Energy and Resources Officials (<http://www.scer.gov.au/workstreams/land-access/mluf/>).

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