



PACIFIC ENERGY SUMMIT

Unconventional Gas and Implications for the LNG Market

FACTS Global Energy

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About FGE

FGE was incorporated as Fesharaki Associates Consulting & Technical Services (FACTS), Inc., in 1983. The company was the first consulting firm to specialize in the oil and gas markets East of Suez and remains one of the very few firms to focus expertise on the region. With the acquisition of Energy Market Consultants (EMC) in 2006, the FGE group is unique in the oil and gas consultancy market, with focused expertise on the Asia-Pacific, Middle Eastern, North American, European, and former Soviet Union markets within a global context.

FGE has over time developed one of the strongest oil and gas analysis teams worldwide. The company has established close ties with important players at the highest levels of management in both the East and West of Suez oil and gas industries. This allows FGE to obtain the latest industry insights to support the company's consulting practice in a volatile energy market.

Over more than a decade, FGE has provided studies and advisory services to national governments, national oil and gas companies, major oil and gas companies, independent oil and gas companies, financial institutions, international and intergovernmental organizations, shipping and storage companies, utilities, consultancies, and engineering design firms.

About the Authors

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Chris Gascoyne leads the oil and gas consulting teams at FACTS Global Energy's Headquarters in Singapore. In this capacity, he oversees a team of professionals providing market analysis and advisory services to many of the industry's leaders—regionally and globally.

Prior to joining FGE, Mr. Gascoyne had over 30 years of experience in marketing, price risk management, trading, business development, and investment analysis in the petroleum industry with BHP-Billiton, Reliance, and Singapore Petroleum, and headed projects for several national oil companies. His experience is primarily in crude oil, but also in the commercial and market development facets of pipeline gas, LNG, refined petroleum products, LPG, and tar sands.

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Alexis Aik heads the group's gas/LNG research and consulting practice. She also serves as the Head of the Information & Analysis Group—which comprises oil and gas analysts that serve all offices of the FGE Group.

At FGE, Ms. Aik's research centers on the developments of the natural gas and LNG sectors, including demand-supply scenarios and pricing issues. She takes a special interest in Asian gas/LNG market dynamics and LNG contract pricing. Her past experience spans both the natural gas/LNG and downstream oil business, where she analyzed the relationships between these two sectors.

Her work has been published in numerous international publications and research journals and has also been filed in U.S. Federal Energy Regulatory Commission (FERC) proceedings. Alexis is formerly a Fellow of the East-West Center Asia-Pacific Leadership Program.

EXECUTIVE SUMMARY

This paper examines the recent development of unconventional gas sources and specifically how they will affect gas markets in China, India, and Australia.

Main Argument

Unconventional gas—comprised of coal bed methane (CBM), tight gas, and shale gas—will likely play a more important role in nations' supplies by 2020. China, India, and Australia are the most likely nations in the Asia-Pacific to follow the United States' example of changing liquefied natural gas (LNG) supplies by exploiting unconventional reserves. China, already a large producer of tight gas, will likely not see greater production in shale and CBM for several more years. India also has potential for CBM extraction due to plentiful coal reserves, but coal blocks allocated for CBM development a decade ago have not produced tangible supplies. Australia, however, has planned projects in all three categories of unconventional gas, which accounts for 45% of Australia's announced LNG export capacity. Though technical, logistic, economic, environmental, and commercial challenges will likely prevent all planned Australian projects from being completed by 2020, the potential for greater Australian LNG exports through unconventional gas is evident.

Policy Implications

- Though extraction efforts are in their nascent stage, India and China could become more self-sufficient in the natural gas market if they pursued unconventional gas sources in as aggressive a manner as Australia.
- U.S. technological advances in shale gas extraction could serve as a model for increased shale gas extraction in Asian nations.
- While Australia is a leading producer and exporter of unconventional gas and stands to greatly increase its exports over the next decade, the country is unlikely to maximize its potential unless high cost and logistical complexities for planned ventures are remedied.
- There is great potential for LNG oversupply in Asia, which could result in lower prices to stimulate greater demand, delays in the start of projects, lower utilization rates in supply projects, or the export of LNG outside traditional consumption centers.

Unconventional gas—whether it be coal bed methane (CBM), tight gas, or shale gas—has existed and been exploited for decades. However, unconventional gas is tipped to play an increasingly important role in the future gas supply mix of many countries, thereby transforming the total supply picture. What has driven this change is primarily an increase in technological capabilities, particularly with respect to shale gas. Horizontal drilling coupled with hydraulic fracturing technology has opened up vast amounts of shale gas reserves, which as recently as a few years ago were deemed economically unfeasible given the high production costs. Nowadays, depending on the fields, these shale reserves can be recovered economically with Henry Hub gas prices at \$4.00/mmBtu (million British thermal units) and perhaps even lower. New technologies as well as companies' increased learning curves have dramatically changed the gas supply picture in the United States.

In the United States, shale gas has proven to be a veritable game changer. Accounting for about 23% of the U.S. gas supply in 2010, the U.S. Energy Information Administration (EIA) estimates that shale gas production will grow about 4.0% annually between 2010 and 2030, reaching 10.6 trillion cubic feet (tcf) and constituting nearly 43% of total U.S. production.¹ Very few such game changers exist in the global energy industry, but shale gas certainly falls into this category. This raises the question: will the shale gas revolution also sweep through other countries? If so, what are the implications for global liquefied natural gas (LNG) markets? Apart from the United States, where developments in this area have already been factored into the LNG projections, the role of shale gas or unconventional gas in other regions has not been as significant.

Within the Asia-Pacific, there are three main countries in relation to unconventional gas—India, China, and Australia. India and China, owing to their sheer size and reserve potential, have been the two most-watched countries. The implication for these two countries is that the ultimate success of CBM development in LNG-importing countries could affect their overall demand for LNG imports. This differs from the view of traditional LNG importers Japan, Korea and Taiwan, which look upon unconventional gas solely as part of their long-term import portfolio. This divergence of views thus raises

¹ Unconventional production, which includes shale gas, tight gas, and coal seam methane, is projected by the EIA to account for 73% of U.S. natural gas production by 2030 (18.03 tcf).

the question of whether China and India will follow in the footsteps of the United States toward greater self-sufficiency, leaving little room for LNG imports.

For Australia, unconventional gas represents more potential supplies to the market than were originally anticipated, as new projects continue to be announced. What is interesting is that unconventional gas in Australia's gas supply scene is not a recent phenomenon; it has been present in the country's domestic gas supply for decades. The push by companies to market this gas beyond Australian shores through LNG liquefaction projects is what has escalated these unconventional gas prospects to the international level.

In this report, FACTS Global Energy (FGE) provides its views on these three markets and the potential impact on LNG imports (for China and India) and exports (for Australia).

China: Huge Untapped Potential

Of the three major types of unconventional gas, China is already a large producer of tight gas, which accounts for a little less than 20% of China's total natural gas production. Tight gas production data is frequently lumped together with data on conventional gas in Chinese government statistics. The other two types of unconventional gas, CBM and shale gas, are still at an early stage of exploration and development, but they have huge potential to grow. Thus, this analysis on China will focus on CBM and shale gas.

In China, development of unconventional gas, namely CBM and shale gas, lags far behind that of conventional natural gas. However, the country has vast CBM and shale gas resources. CBM exploration and development has been occurring in China since the 1990s, but production levels are extremely low at present. Shale gas development, on the other hand, is currently in its infancy, with exploration activities commencing in the early 2000s. First production only commenced at the end of 2009, giving shale gas a much shorter history in China compared to CBM.

CBM

Reserves. China reportedly has more than 1,000 tcf of CBM resources, and an expansion in current CBM production rates could affect the nation's appetite for LNG imports. Yet the question remains, by how much? China's gas demand is expected to grow 16% annually through 2020 and at a slower rate of 3% from 2020 to 2030. The inability of Chinese indigenous gas production to keep abreast of surging demand was the driving factor behind Beijing's decision last decade to introduce LNG into the nation's energy mix. But an increasing number of domestic and foreign companies have evinced interest in China's CBM industry, which could eventually lead to higher CBM production levels—assuming, of course, that China's resources can be developed at a reasonable cost and will enjoy access to pipeline capacity. If both assumptions hold true, and cheap quantities of indigenous CBM can be transported to high-value markets in the east, a percentage of China's LNG demand possibly would be displaced. On the other hand, more plentiful (and relatively cheap) domestic gas production might not only encourage overall gas use, but also broaden China's pricing and resource pooling options. This in turn would enable Chinese LNG importers to offset high LNG procurement costs and actually increase the nation's appetite for imported LNG.

FIGURE 1 **China's CBM Resources**

| China CBM Resources (tcf) | | Current Production (bscf/d) | |
|----------------------------|-------|-----------------------------|------------|
| Total resource* | 1,300 | 2005 | Under 0.04 |
| Recoverable | 385 | 2009 | 0.7 |
| Proven geological reserves | 7 | 2010 | 0.9 |

*Within depth of 2,000 m

Figure 1 shows China's CBM statistics based on the latest official survey conducted by the Chinese Ministry of Land and Resources (MLR). Depending on the definitions and proven degrees, the resource reserves are estimated to be a massive 1,300 tcf (or 36.8 trillion bcm). These reserves are the third-largest in the world, just behind Russia's 3,991 tcf and Canada's 2,684 tcf. However, out of the resources identified above, the cumulative proven geological reserves at the start of 2010 stood at only 7.1 tcf, of

which 2.2 tcf is recoverable. Production figures have also been modest at 0.9 mmscf/d in the beginning of 2010.

Many players are currently involved in the CBM business, with China United Coalbed Methane Corporation (CUCMC) and PetroChina being the most active. State-owned CUCMC was founded in May 1996 and was initially a 50-50 joint venture between the state-owned China Coal Energy Corporation and China National Petroleum Corporation (CNPC, the parent company of PetroChina). Until mid-2007, CUCMC was the monopoly in China's CBM business, holding the only rights to sign contracts with foreign companies. The rule has changed since late 2007 when PetroChina and Sinopec were given the authorization to conduct CBM business and sign Sino-foreign CBM contracts in light of the slow progress of CBM development. In 2008, CNPC formally left CUCMC, and its listed company, PetroChina, has since pursued the CBM business independently. Other state oil companies (Sinopec and CNOOC) have also been given the rights to attract foreign investment in the CBM business. In early January 2011, it was reported that CNOOC is negotiating for a 50% stake in CUCMC. If successful, CNOOC will be positioned to provide both financial resources and expertise in dealing with foreign companies to help speed up the development of CUCMC's CBM projects. In the longer term, the acquisition of CUCMC will provide CNOOC with a great platform to transfer core skills developed through its foreign ventures in unconventional gas plays abroad to the domestic market.

The potential appears strong especially, with large investments being allocated to the sector by Chinese state-owned companies.² Foreign investors have been attracted to China's CBM business because of a series of preferential policies that encourage and support overseas investment to enter the coalbed methane exploitation sector. As for now, CUCBM has at least eighteen CBM cooperative contracts with eight international companies from the United States, Canada, Australia, and Hong Kong. Separately, PetroChina has eleven CBM contracts with ten international companies from the United

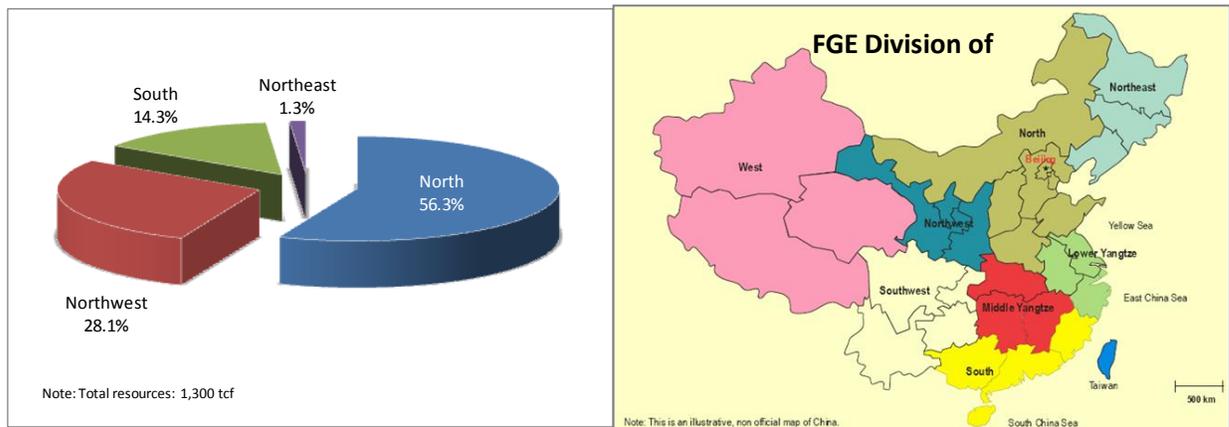
² PetroChina's involvement in CBM projects since 2008 has substantially increased the future growth potential of CBM. The company invested almost \$660 million in 2008 and 2009, with two-thirds of the investment spent in 2009 alone. CUCBM has also picked up investments, spending approximately \$293 million on CBM investment in 2009 and more in 2010. Sinopec is a newcomer in the business and has recently stepped up its efforts.

States, United Kingdom, Canada, Australia, and Hong Kong. Foreign participation will be vital for the development of China’s CBM sector by bringing in the necessary capacity, thereby mitigating investment risks, and expertise and technology. That being said, the issue at hand remains that several foreign companies are not active enough to aid in the faster development of the industry, instead mostly adopting a “wait and see” approach.

Transportation and Utilization of CBM to the markets

The interplay between CBM and LNG will be dependent on distribution, economics, and utilization of CBM relative to LNG. Most of China’s CBM resources are located in the northern region of China as seen in **Error! Not a valid bookmark self-reference.**³

FIGURE 2 China’s CBM Resources Mostly Located in Northern China



Up until 2009, China had virtually no long-distance CBM pipelines, though this was in part due to low CBM production in the first place. PetroChina built China’s first commercial CBM pipeline, having a capacity of 290 mmscf/d (million standard cubic feet per day) and linking the Qinshui producing field with the West-East Pipeline.

³ FGE’s division of the North and Northeast of China includes the following provinces: Northeast (Heilongjiang, Jilin, Liaoning); Northwest (Gansu, Ningxia municipality, and Shannxi); and North (Beijing municipality, Hebei, Henan, Inner Mongolia autonomous region, Shandong, Shanxi, and Tianjin municipality).

China's total CBM transportation pipeline capacity stood at 387 mmscf/d by the start of 2010.

In part because of the limitations in connecting the producing regions to the consuming centers, actual utilization of CBM is low. China's CBM production is sourced from both surface wells and coal mines. Only two-thirds of production from surface wells is consumed, while less than one-third of coal mine production is consumed.⁴ Prior to PetroChina's commercial CBM pipeline in late 2009, CBM was mainly used in the residential sector of the areas around coal mines. Use of CBM for power generation has only just started. Overall utilization of CBM in China stands at only 38% of total production.

Use of the gas is expected to increase, expanding to farther away consuming areas such as coastal regions, with the connection of more CBM pipelines to conventional gas pipelines. Until more pipelines are brought online, companies are adopting innovative means to reach less accessible markets via liquefied CBM (LCBM) projects and compressed CBM (CCBM). There is currently one LCBM plant in operation, two under construction, and one proposed with a combined total capacity of 152 mmscf/d. CCBM project capacity in China stands at 19 mmscf/d.

Production Outlook

CBM. Although exploration, development, and utilization of CBM remain at low levels at present, the potential for China's CBM industry is still great, owing to its rich resources, solid government support with a series of preferential policies, and foreign participation. Immediate targets for 2010 under the eleventh five-year plan (covering 2006–10) were to produce 1 bscf/d of CBM in 2010 with utilization at 774 mmscf/d. Those targets have been missed. Separately, China's long-term program for CBM also set goals for 2015 and 2020 that seem rather ambitious.⁵ The Chinese government is

⁴ Another key consideration for the utilization of CBM in China is cost and overall economics. Exploration and production costs can be challenging, while long-distance pipeline tariffs are similar to or higher than those for conventional gas. Companies may also have problems accessing PetroChina's long-distance gas pipelines.

⁵ China's medium-to-long-term program for CBM calls for production to increase to 2 bscf/d in 2015 and 5 bscf/d by 2020.

currently in the process of rolling out its twelfth five-year plan (covering 2011–15), and vows to step up efforts to develop CBM further. With all factors considered, our base-case projections are that China will increase CBM production to 1.3 bscf/d in 2015 and 2.0 bscf/d by 2020.

Shale. Unlike CBM, China’s actual investment in shale gas exploration and development has barely started. China had conducted sporadic research on shale gas before the 1990s, but more serious research work did not begin until 2004, when the MLR collaborated with domestic research organizations. In 2007, China signed its first joint shale gas research agreement with the U.S. Newfield Exploration Company for an area in Sichuan Province. There is no distribution line and utilization of shale gas so far.

China has recently begun to focus on shale gas as a potential new source of gas supply to meet the country’s growing energy need. The government also intends to use shale gas as a cleaner energy to address rising environmental challenges. In November 2009, PetroChina signed its first agreement for cooperative exploration and development of shale gas with Shell for the Fushun-Yongchuan block in Sichuan Province. Prior to that, the Sino-U.S. Shale Gas Resource Cooperation Initiative was signed in Beijing in October 2009 during President Obama’s visit to China as part of efforts to develop clean energy in China through U.S.-China cooperation.

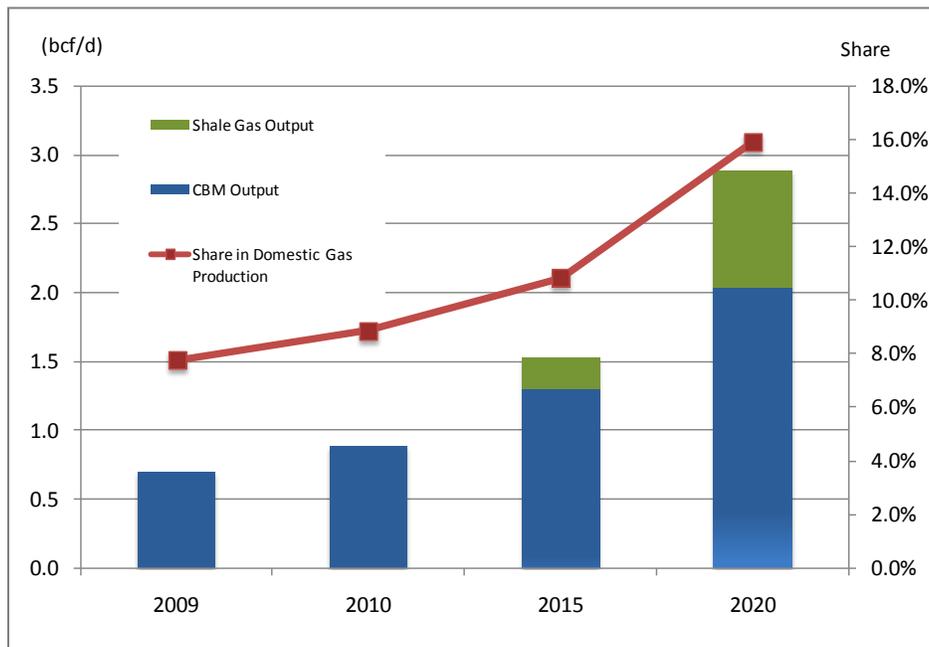
Other international oil companies (IOC) and foreign national oil companies (NOC) are also currently looking to invest in China’s shale gas exploration and development projects. BP and Chevron have been in discussion with Sinopec on shale gas development in China, while Statoil of Norway is also interested in investing in those projects.

FIGURE 3 China’s Shale Gas Statistics

| China Shale Resources (tcf) | |
|-----------------------------|-------------|
| Total resource | 3,532 |
| Recoverable | 918 - 1,589 |
| Proven geological reserves | nil |

China claims to have 3,532 tcf (100 trillion m³) of shale gas resources and 918–1,589 tcf (26–45 trillion cbm) of recoverable resources. However, nothing has been formally proven, and China presently has no shale gas production. Based on the current pace of development, we believe that China’s shale gas production will not materialize for a few years. Production could reach 0.2 bscf/d in 2015 and 0.9 bscf/d by 2020 under our base-case forecast.

FIGURE 4 Outlook for Unconventional Gas Production in China



Adding CBM and shale gas together, the total unconventional gas output in China could reach 1.5 bscf/d in 2015 and 2.9 bscf/d in 2020 under our base-case scenario. If these projections hold, unconventional gas output will account for 16% of China’s total domestic gas (natural gas plus unconventional gas) by 2020.

China has great potential to develop unconventional gas in the long run if sufficient investment is secured. Various factors, such as price regime, government support, infrastructure, and structure of investment companies that hindered the past development of CBM have improved. China now has a greater need for gas. If the prices are right, investment of CBM and shale gas will be spurred. The size of unconventional gas development in China remains a huge uncertainty. If the production of unconventional

gas is large enough, future LNG imports may be affected. However, FGE believes that the direct impact on LNG will be limited through 2020. CBM will continue to meet demand growth in the inner northern regions of China, while LNG's role will continue to meet the coastal region's gas demand. Under the above base-case scenario for unconventional gas production, China is expected to import 25.2 mmtpa (million metric tons per annum) and 37.5 mmtpa of LNG in 2015 and 2020, respectively.

India: In the Development Stage

The unconventional gas situation in India is similar to that in China, where developments in shale gas trail those in CBM. As the world's third-largest coal producer, India is obviously a good candidate for CBM exploitation. Its CBM resources are estimated to be 92 tcf and mainly concentrated in the northeast and western parts of the country. Current production levels are modest, at around 3.9 mmscf/d, but India formulated a policy for CBM development back in 1997, and the first CBM round was launched in May 2001. A total of 26 blocks were allotted for commercial development after the first three rounds of CBM bidding. Out of these 26 blocks, 2 blocks were awarded by the government on a nomination basis to the state-owned Oil and Natural Gas Corporation (ONGC), Coal India Ltd. and 1 block to Great Eastern Energy Corporation Ltd. (GEECL) through foreign investment promotion. The fourth round (CBM-IV) was announced in April 2009, with 26 bids received for 8 out of 10 blocks on offer.

Though several players are carrying out CBM exploration activities in India, the fact remains that companies that were allocated CBM blocks ten years ago have yet to make significant progress. CBM companies have managed to trace an aggregate of only 8.9 tcf of gas in five mines, and only one project has started commercial production. GEECL became the first commercial CBM producer in India when it commenced production on July 14, 2007, from its Raniganj block in West Bengal. Four blocks are in development phase, including two blocks in Sohagpur (Madhya Pradesh) where Reliance Industries Ltd. (RIL) has a 100% stake; a block each in Raniganj (West Bengal) belonging to Essar and GEECL, respectively; and lastly the Jharia block (Jharkhand)

where ONGC has a 100% stake, Meanwhile, Essar Oil was only expected to commence CBM production from its block in Raniganj, in the third quarter of 2010.

New Delhi hopes to see CBM production reaching 0.13 bscf/d by 2012. However, we remain skeptical regarding the shorter-term progress of CBM production. Most of India's CBM blocks are either along the northeastern belt or scattered in states such as Madhya Pradesh and Tamil Nadu that do not have good pipeline connectivity. Energy companies in India are developing a gas grid that will improve connectivity to these states by 2013.

Internal politics have also hindered the development of CBM in India: the ongoing tussle (prevalent since 2007) between India's coal ministry and oil ministry (where each is staking a claim on these coal blocks) is slowing down substantially any development. There is no indication of whether this highly politicized issue will reach a resolution anytime soon. Consequently, investors are cautious. Like China, India's appetite for gas is extremely price-sensitive, and large future flows of reasonably priced domestic CBM could help control domestic gas prices. This could help India to not only further develop its internal gas market and get "hooked" on gas but also create more opportunities to dilute the higher prices of imported LNG.

GEECL currently sells CBM as compressed natural gas (CNG). GEECL has also signed a memorandum of understanding (MOU) with Indian Oil Corporation for sales of CBM as piped natural gas and CNG. Indian and foreign companies such as ONGC, BP, RIL, Essar Oil, Arrow Energy, GAIL Ltd., and GEECL realize that there is a huge potential for CBM sales to steel and sponge iron plants, ceramic plants, glass manufacturers, and chemical companies along the eastern parts of the country. Apart from the issues of CBM exploration that need to be further explored, direct sales of CBM to the power sector will be key. As the Indian market is price-sensitive, private players such as RIL and Essar will find it difficult to market CBM to the power sector, because the supplier and consumers will need to arrive at a mutually agreeable price.

Power companies prefer coal over CBM gas as feedstock due to the higher costs associated with latter. Companies such as RIL are also looking to convert CBM to CNG. However, as mentioned above, because of poor pipeline connectivity that limits the ability to deliver the gas to end-users that are around 250 km away, this idea is still in

nascent stages. RIL is presently considering the idea of delivering the product via trucks and tankers, which is also at a nascent stage.

BP and Arrow Energy were two overseas players that were involved in CBM exploration activities mainly in the eastern and northeastern parts of India. However, BP, which had a 100% stake in the Birbhum block in West Bengal and was awarded the same in 2006, decided to quit the block in the third quarter of 2010. Arrow Energy, which has exploration rights in three blocks via various consortia that include GAIL, EIG Energy Infrastructure, and Tata Power, also was looking to relinquish its exploration licenses in all three.

Most investments in CBM projects involve private players. However, it is highly likely that when CBM production starts in a big way, the government will step in to assign volumes, as is the case with the KG-D6 block. Private and foreign investors are aware of the Indian government's intervention with indigenous production (such as with KG-D6), and this is likely to keep them at bay from any investment in CBM. We expect that CBM production will reach 425 mmscf/d by 2020 and around 600–700 mmscf/d by 2030. Like KG-D6 gas, we anticipate that the bulk of CBM gas will go to “sensitive” players in the power and fertilizer sectors who are short on gas supplies. Hence, CBM production is unlikely to affect the volume or price of LNG brought into India.

Shale

The development of shale gas in India, similar to in China, is still in its infancy and lags behind CBM. However, unlike China, India does not have a timeline on when it will commence shale gas production. India's upstream regulator, the Directorate General of Hydrocarbons (DGH), has identified the Assam Arakan region in the northeast, the Cambay basin in the west, the Krishna Godavari basin in the east, and the Vindhya in the central part of the country as regions with potential shale gas reserves. However, the exact resource estimates are not known with any degree of accuracy, as there is no data available. ONGC involved Schlumberger in carrying out a \$36.5 million pilot project in the former's existing acreage in the Damodar basin of eastern India to estimate shale gas potential. In line with its plans to conduct the country's first auction of shale gas exploration blocks, the DGH is currently mapping out a regulatory framework and a

policy for shale gas exploration. The auction round is scheduled to take place around June 2012. The DGH has broadly laid out three phases in the lead-up to the first round:

- Phase I: Evaluation of oil shale resources, which involves geological mapping and geochemical analysis of oil shale (this phase is now complete)
- Phase II: Techno-economic feasibility for extraction, environmental impact, preparation of model production sharing contracts (PSC), and framing legislation (this phase is ongoing)
- Phase III: Bidding for shale blocks and awarding the blocks (this phase is scheduled to take place by June 2012)

Due to the lack of resource estimation at this stage, there is no certainty on India's potential in terms of shale gas production.⁶ As such, our projection of the country's conventional gas production is confined to CBM. However, FGE believes that shale gas will rapidly come to the attention of the industry, as Indian companies such as RIL gain experience through investments in U.S. shale gas and foreign companies bring their expertise and investments into the country.

Australia's Unconventional Gas: The LNG Game Changer of the Far East?

Together with Qatar, Australia is projected to be a twin pillar of new LNG supply for the Asia-Pacific between 2010 and 2020. Based on existing LNG plants as well as on the facilities currently under construction, Australia will boast almost 56 mmtpa of nameplate LNG export capacity by 2014, thereby dwarfing every other LNG-producing country's capabilities save Qatar's.

This number could grow higher if even a handful of the planned unconventional gas-to-LNG projects materialize. Plans are afoot in Australia for LNG projects based on gas feedstock originating from shale gas, tight gas, and CBM projects sited across the country. However, the greatest concentration of planned projects will use CBM feedstock, and these are concentrated in the northeast Australian state of Queensland. One such project was the first of its kind to achieve final investment decision (FID) at the

⁶ Preliminary findings indicate presence of significant reserves but there is no official data on India's shale gas reserve potential

end of October 2010 and is currently under construction—the BG Group’s Queensland Curtis LNG (QCLNG) project. At 8.5 mmtpa capacity, the project is a prime candidate for expansion to a third train, based on the size of the resources and number of sales agreements. A second such project, the 7.8 mmtpa capacity GLNG sponsored by Santos, Petronas, Total, and KOGAS, reached FID in January 2011. No fewer than nine other LNG projects with unconventional gas as feedstock have been announced in Australia, which could provide up to 66 mmtpa of new LNG supply for Asia-Pacific customers. Excluding Australian LNG projects currently under construction, unconventional gas projects account for over 45% of Australia’s announced LNG export capacity. Australia’s unconventional gas-to-LNG projects have the potential to significantly enhance Australia’s overall importance as a regional LNG supplier between 2010 and 2020 and, therefore, merit further scrutiny.

The domestic market for gas in Australia is relatively small, and existing production of unconventional gas—in reality all CBM—for domestic use was only 0.1 tcf in 2008. Thus, the economic demonstrated resources (EDR) of CBM represent more than one hundred years of CBM production at current production rates. Yet the size of unconventional gas resources in Australia is vast. A recent national assessment found that all identified gas resources total approximately 357 tcf—equal to around 180 years of gas at current production rates.⁷ Of this, some 173 tcf are unconventional gas resources⁸ (see

Figure 5). In addition, a further 250 tcf of CBM could be “in ground,” while the amount of shale and tight gas in ground is simply unknown.

FIGURE 5 Australian Unconventional Gas Resource Assessment

| Resource Category | CBM (Tcf) | Tight + Shale Gas (Tcf) |
|-------------------------------------|--------------|----------------------------|
| Economic Demonstrated Resources | 15 | - |
| Sub-economic Demonstrated Resources | 27 | - |
| Inferred | 111 | 20 |
| Total | 153 | 20 |

⁷ Australian Bureau of Agricultural and Resource Economics (ABARE), Australian Energy Resource Assessment, 2010.

⁸ Includes EDR sub-economic demonstrated resources (SDR), and inferred resources.

The question remains, how much of Australian unconventional gas resources will become LNG?

Australian LNG Export Potential

Australia's LNG export potential has few peers. There's currently approximately a mere 20 mmtpa of existing export capacity, but there is roughly an additional 36 mmtpa currently under construction, which will increase the nation's nameplate liquefaction by 180%. On top of that is approximately a further 150 mmtpa of export capacity, from both conventional and unconventional feedgas, in various planning stages (**Figure 6**). It is perhaps unfair to lump projects in such different stages of development within this single "planned" category, as some projects clearly have a better chance of materializing than others. A number of these projects are in their extreme formative stages, such as the former LNG Newcastle project in the eastern state of New South Wales, and are clearly in a different league than planned expansions of projects currently under construction (for example, Train 3 of the BG-led QCLNG project in eastern Australia) or greenfield projects such as the Chevron-led Wheatstone LNG venture, which already has an impressive slate of customers and is exceedingly likely to succeed.

FIGURE 6 Australian Liquefaction Capacity Profile (January 2011)



Projected Supply from Australia

Australia has more than 20 LNG export projects in various stages of development, which translates into potentially more than 180 mmtpa of liquefaction capacity.⁹ The vast majority of these projects are seeking a start-up date before 2020, at least for their first phases. Eleven of the projects that have been announced¹⁰ are unconventional gas-based, which equates to a range of 54–72 mmtpa of liquefaction capacity (see

Figure 7).¹¹ The sheer number of projects near the Queensland town of Gladstone has led observers to believe that some projects may be consolidated, but to date, only two projects have even come close: Australia Pacific LNG and QCLNG, who have an agreement for gas production from a couple of jointly owned tenements to support both ventures. True consolidation will most likely happen in a project’s more formative years,

⁹ This figure includes projects under construction and announced

¹⁰ Announced projects include the expansion of QCLNG, already under construction, and exclude Sun LNG, which has been abandoned due to takeover by QGC and subsequently BG. A number of these projects have no announced start date.

¹¹ Liquefaction capacity has not been clearly defined for some projects.

given the need for partners to be involved in project design. But at least three projects have already completed basic design and engineering, rendering consolidation much more difficult and unlikely.

FIGURE 7 Announced Unconventional Gas-to-LNG Projects in Australia

| Project | Sponsors | Capacity | Startup |
|-------------------------|--|--|------------------------------------|
| Abbott's Point LNG | Energy World Corporation | 2 x 0.5 mtpa (initial); up to 4 trains of 0.5 mtpa each | TBD |
| Arrow Energy LNG | Shell, PetroChina | 4 x 4 mtpa | 2016 |
| Australia Pacific LNG | ConocoPhillips and Origin | 2 x 4.5 mtpa (initial); Expansion trains to 16-18 mtpa | 2016-2018 |
| Fisherman's Landing LNG | LNG Limited, TBD? | 3 x 1.75 mtpa | TBD |
| Gladstone LNG | Santos, Petronas, Total, Kogas | 2 x 3.9 mtpa (initial) | 2015 |
| Kimberley LNG | Oil Basins Ltd, LNG Ltd | TBD [^] | TBD |
| Newcastle LNG | Eastern Star Gas, Toyo Engineering, Hitachi, Marubeni | Phase I: 2 x 0.5 mtpa. Expansion trains to 4 mtpa | 2014 |
| Queensland Curtis LNG | BG, CNOOC, Tokyo Gas | 2 x 4.25 mtpa under construction; 1 x 4.25 mtpa (expansion potential) | T 1: 2014; T2 6-12 months later |
| Southern Cross LNG | LNG Impel | 0.7-1.3 mtpa | TBD |
| TBD | Metgasco and Flex LNG or LNG | 1 x 3.0 mtpa | TBD |
| TBD | Beach Energy, Itochu Corp | ? x 1 mtpa [^] | TBD |

[^] Combination unconventional and conventional gas as feedstock

How Credible are Unconventional LNG Projects?

There is little question that many of the unconventional gas to LNG projects under development in Australia have multiple positive attributes. Many are sponsored by creditworthy, seasoned pipeline gas and LNG players, and some have achieved key project milestones, such as the award of front-end engineering and design (FEED) contracts and the selection of engineering, procurement, and construction (EPC) contractors. Several ventures have even signed LNG sales agreements with buyers and secured significant funds from the sale of equity, thereby further improving their ultimate chances of success. Hence, unconventional LNG projects—admittedly, some more than others—represent a considerable source of competition to the various LNG export projects in Western Australia and the Timor Sea, which are based on offshore non-associated gas reserves.

However, Australia's unconventional projects also face undeniable technical and commercial challenges. These include the logistic, economic, and environmental

problems posed by disposing of large quantities of water or fracturing fluids; the questionable desirability of “lean” CBM-based LNG to Far East LNG buyers; and the threat posed by non-associated, gas-based LNG export projects elsewhere in Australia, some of which have enjoyed a marked degree of success in recent months. Like all Australian-based LNG projects, unconventional gas ventures also face the challenge of working in a very high-cost environment, where qualified manpower is not only expensive to obtain but also in short supply.

Some observers have argued that unconventional gas-to-LNG projects have more competitive advantages than other projects:

- Projects with smaller liquefaction capacities may not achieve the economies of scale that accompany bigger projects, but they have their own advantages.
 - Smaller projects will require fewer wells, thereby reducing the complexity of the project’s upstream component.
 - Recent LNG sales activity indicates a “piecemeal approach” by customers that favors smaller projects. Due partly to demand uncertainty and a desire to diversify supplies and risk, LNG buyers have been contracting for supplies in 1–2 mmtpa chunks. Hence, smaller CBM projects can sell out at least a first train and use it as a basis to proceed with the project. Larger ventures, on the other hand, would need to hold out for one big sale—a relatively rare occurrence in today’s market¹²—or attract multiple smaller buyers in order to proceed. This in turn renders the marketing process harder and project timing more uncertain.
- Projects sponsored by experienced LNG developers who also have existing relationships with customers may be in a better position to secure sales. In a similar vein, project developers with their own LNG supply portfolios are in a good position to contract for unconventional LNG volumes to boost marketing and development efforts, making the project more attractive to financiers.
- One or two CBM projects feature liquefied petroleum gas (LPG) storage facilities, indicating a willingness to bear the additional expense of blending LPG and LNG

¹² The recent 3.5 mmtpa sale to Korea Gas Corporation (KOGAS) by Gladstone LNG (GLNG) is an exception.

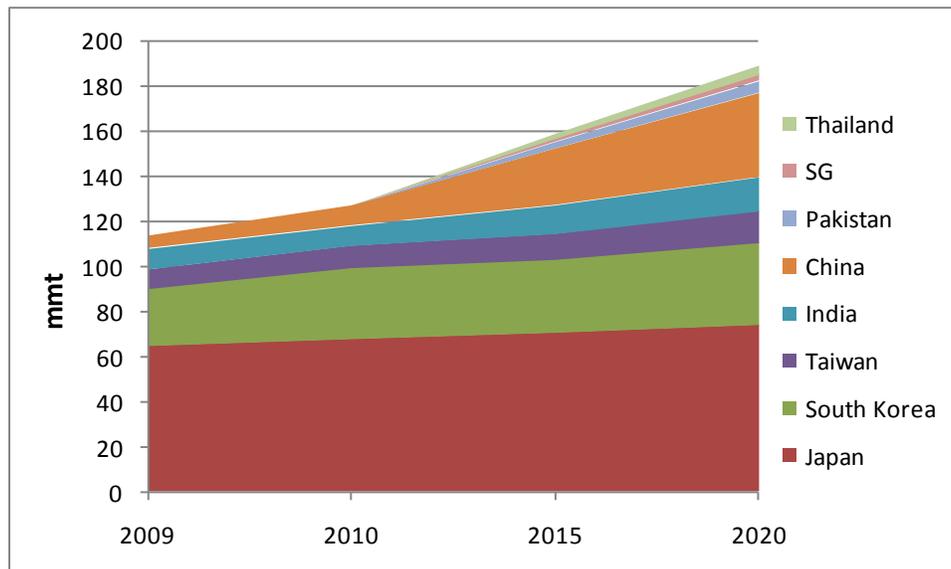
to meet customer specifications. Given that many established Asian LNG buyers favor richer streams of LNG to comply with downstream gas quality specifications, these CBM-based LNG projects may be more attractive.

Is There a Large Enough Market to Support These Projects?

Some unconventional gas-to-LNG ventures pose significant challenges to other planned Australian ventures in Western Australia and the Timor Sea. Although greenfield projects such as Chevron's Wheatstone play have enjoyed marked success over the last year or so, many others are stymied by technical, political, and shareholder challenges. This is evidenced by the LNG marketing triumphs at Gladstone LNG and QCLNG. The marketing success—and the achieved affirmative FIDs—of these Australian CBM-LNG ventures could make it harder for other liquefaction ventures elsewhere in Australia that are battling for market share.

The onus is clearly on Australia to capture as much Asian LNG market share as possible by the end of the decade. Total regional demand is forecast to climb from the current level of around 114 mmt to just over 190 mmt in 2020, so clearly there is demand for additional quantities of LNG. Growth in Asian LNG demand will be spurred by a regional recovery from the 2008–09 economic crisis, as well as individual governments' efforts to boost the role of gas in the primary energy mix (see **Figure 8**). The commencement or ramp-up of LNG imports in countries such as Pakistan, Singapore, and Thailand will contribute further toward Asia's overall bottom line during the forecast period. However, the volume of this demand, which is not yet contracted, falls to some 71 mmtpa in 2020.

FIGURE 8 Forecast Asia-Pacific LNG Demand through 2020



Impact of Australian Unconventional LNG on the Asia-Pacific Market in 2020

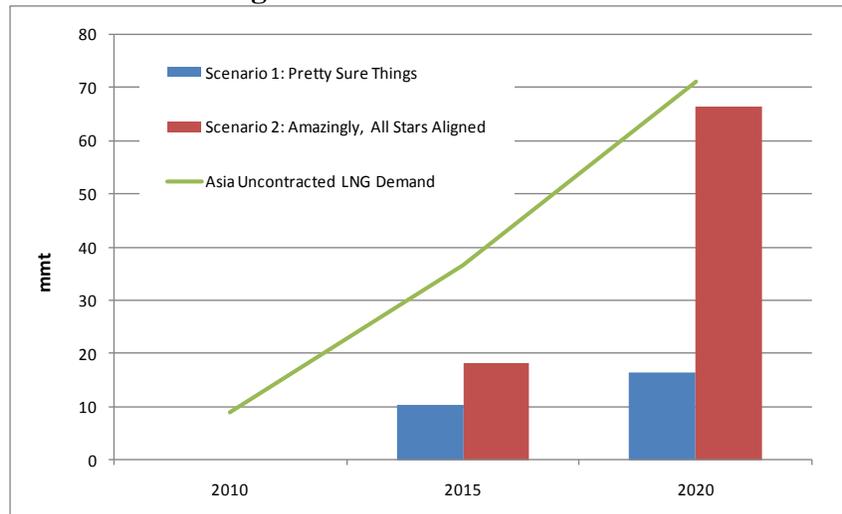
There are two scenarios at the extreme ends of the spectrum of possibility that can be used to illustrate the potential impact on the Asia-Pacific market of unconventional gas-to-LNG from Australia.

In the first scenario, “Pretty Sure Things,” only the first phase of QCLNG (under construction) and Gladstone LNG (GLNG) (achieved FID in January 2011) are included, representing a fairly minimal volume of unconventional LNG supply from Australia. If no other projects see the light of day, these two seem like pretty sure things at present. Together they total 16.3 mmtpa, or about 23% of the forecast uncontracted demand in 2020 (see **Figure 9**).

In the second case, “Amazingly, All Stars are Aligned,” all possible projects under construction and in various stages of planning are included. This covers ten projects,¹³ including expansion plans for QCLNG (the first phase of which is already under construction), totaling over 66 mmtpa in 2020. It would indeed be amazing if every single one of these projects were to come to fruition. If this were to occur, they would account for just over 90% the forecast uncontracted demand in Asia in 2020.

¹³ One of the eleven announced projects listed in Figure 7 (Kimberley LNG) does not have a quantified capacity.

FIGURE 9 Impact of Australian Unconventional LNG Supply on Asia-Pacific Uncontracted Demand through 2020



The realization of the Australia’s LNG supply plans is likely to lie somewhere between these two extremes (though FGE’s view sits closer to the volumes represented in the first scenario). With the first scenario, the impact on the Asia-Pacific LNG market at 2020 is not insignificant. The second scenario could only come to pass if there were no other supply entering the Asia-Pacific basin, either from planned Asian projects outside of Australia or from Middle East or Atlantic basin supplies. This will most certainly not be the case. A further 66 mmtpa of conventional Australian LNG supply alone, over and above unconventional LNG, is planned by 2020.

On paper, the potential for Asian LNG oversupply in 2010–20 currently looks great, given the threat of large-scale Qatari diversions east of Suez and the myriad of regional (not confined to Australia) LNG projects slated for start-up around mid-decade. Then there’s also the massive slate of planned LNG export projects hoping to reach fruition by 2020, thereby potentially further contributing to Asia’s supply pool. FGE believes that in reality the market will never be in surplus. Something has to give in order for the market to balance. It could be a combination of a reduction in price (to stimulate demand), delay in project start-up dates, and lower utilization rates in supply projects.

There is clearly not enough uncontracted LNG demand forecast to be available in Asia in 2020 to support the construction of so much supply capacity, unless Australian or

other projects originally targeting supply to the Asia-Pacific basin successfully market their volumes outside their traditionally considered natural market, selling instead to the growing markets of the Middle East or South America. This phenomenon has not yet occurred.

What Could Constrain Australian Unconventional LNG Projects?

One of the “things that might give” and thereby prevent regional oversupply is the failure of various planned Australian LNG export projects to materialize. This could happen for a variety of reasons, such as Australia-specific societal structural, regulatory, political, and economic factors. Despite Australia’s vast LNG supply potential and the country’s position as a pillar of regional LNG supply over the next decade or two, it will not necessarily be smooth sailing for the island continent. The country has not built more than two LNG trains at the same time, and the scale of planned expansion has never been achieved elsewhere in the world outside of Qatar. Given the importance of Australia to Asia-Pacific LNG supply, FGE has identified five key risks for Australian LNG projects going forward and assessed the degree of impact of each risk on final supply.

- *Societal structure (shortages of workforce skills)*—Both the petroleum and mining sectors are competing strongly for a limited pool of skilled and unskilled labor. Manpower shortages will have two potential impacts on LNG exports: schedule delays and wage escalation.
- *Regulatory (obtaining requisite land access and environmental approval)*—Native title issues could limit exporters’ access to an LNG export site, resulting in costly and prolonged litigation. Delays could lead to missing the window of opportunity for the targeted LNG market. Likewise, stringent environmental regulations governing LNG project development and operation could add to project costs in a country already known for being a high-cost environment.
- *Fiscal (impact of the proposed Mineral Resources Rent Tax on planned projects)*—Uncertainty about the tax’s ultimate final parameters has been a strain for CBM-based LNG export projects as companies struggle to determine if their projects will be profitable under multiple scenarios.

- *Environmental (emissions trading/carbon tax)*—The impact is ultimately uncertain because Australia’s climate legislation has not been outlined, and the penalty required from pollution emitters has yet to be decided.
- *Local content requirements*—The highest-value contracts will probably go to foreign companies, owing to Australia’s labor shortage and companies’ existing relationships with overseas contractors. Every effort will be made to maximize local content to the legal extent possible, although the final impact of local content structures on LNG projects materializing is negligible.

The potential for Australian CBM developments could be significant. Along with Qatar, Australia will be a pillar of LNG supply growth through 2020, and CBM might be the primary contributor. That said, significant obstacles to achieving this growth remain. Water handling issues are the foremost concern, with projects allocating up to \$1 billion, or almost 10% of capital, to water issues,¹⁴ but labor issues are also critical. Australia is experiencing a labor shortage as gas projects compete with the development of other commodities.

Australia’s shale gas potential has yet to be adequately delineated but could be massive. Preliminary results are very encouraging. The U.S. experience suggests that shale gas project economics are heavily dependent on the liquids ratio. No information has been released to the market yet on shale gas resource quality. Without significant liquids revenue to bolster project economics, shale gas is likely to be less economic than CBM. Consequently, while there may be some location-specific shale gas developments destined for the domestic market,¹⁵ shale gas is unlikely to be the base for export development in Australia. Because Australian LNG projects are “resource rich, market poor,” shale gas developments may need to wait in the queue.

¹⁴ See the QCLNG project’s environmental impact statement.

¹⁵ Shale gas produced in the Perth Basin may be delivered at rates competitive to long-haul Barrow Basin conventional gas.

Conclusion

Unconventional and shale gas projects are in their infancy in Asia, but the outlook is promising. China is leading Asia's prospective unconventional gas development. Though still in early stages, China, as well as Asia as a whole, could reap significant rewards from unconventional gas developments going forward. If Asia can replicate what has happened in the United States, there will be major implications for the global LNG market. After all, Asia currently accounts for over 60% of global LNG imports. Although it is too early to determine how large an impact shale gas will have on Asia's gas balance, given that a surge in unconventional output could potentially back out LNG from the largest regional market in the world, the situation bears close monitoring. FGE, however, believes that in the near future an unconventional gas revolution in Asia is unlikely from India and China.

From a supply point of view, unconventional gas to LNG supply projects will have a greater impact on the international level of gas supply through 2020 than will potential domestic supplies in China and India. The two likely supply projects from Australia for unconventional gas-based LNG, QCLNG and GLNG, will add 16.3 mmtpa of LNG to the market. The additional supply may be dwarfed by the total announced projects in Australia, but still represents a significant volume—almost equivalent to China and India's combined LNG imports or half Korea's LNG imports in 2010. This is a huge step for the LNG industry, as the success of these two projects will set the benchmark for future unconventional LNG supply projects around the world.