

Bernstein Asia-Pac Energy: Coal Bed Methane: Is It Time for China's Unconventional Gas Revolution?

Ticker	Rating	CUR	5/14/2010 Closing Price	Target Price	TTM Rel. Perf.	EPS			P/E			Yield
						2008A	2009E	2010E	2008A	2009E	2010E	
386.HK	M	HKD	6.02	7.90	-40.5%	0.80	0.83	1.03	7.5	7.3	5.8	3.4%
SNP	M	USD	76.35	102.00	-30.1%	9.03	10.75	13.29	8.5	7.1	5.7	3.5%
857.HK	O	HKD	8.76	12.50	-30.9%	0.64	0.91	1.33	13.7	9.6	6.6	3.3%
PTR	O	USD	110.17	161.00	-21.4%	8.25	11.71	17.16	13.4	9.4	6.4	3.4%
MXAPJ			407.77			23.86	30.32	35.27	17.1	13.4	11.6	2.5%
SPX			1135.68			61.70	83.20	98.56	18.4	13.7	11.5	1.9%

O – Outperform, M – Market-Perform, U – Underperform, N – Not Rated

Highlights

- **China has over 1000TCF of coal bed methane resources and ambitious plans to increase CBM production to 5bcf/d which by our estimates would be 25% of total gas production by 2020.** While this is an aspirational target, it signifies China's commitment to push forward the development of domestic unconventional gas resources.
- **Despite the enormous resource base and production potential, coal bed methane reservoirs in China are technically challenging to produce.** Although Chinese coals have high gas contents, they are under-saturated and have lower permeability relative to coals in more prolific basins such as the San Juan in the US or Bowen/Surat basins in eastern Australia.
- **To overcome these technical challenges, horizontal fraced wells with multilateral well bores offer the best means of delivering commercial scale production.** Data from recent pilot projects in the Ordos and southern Qinshui basin is encouraging with flow rates now exceeding 1mmscf/d. While these wells are more expensive, we believe this is an important step forward in realizing large scale CBM production in China.
- **Our analysis indicates that CBM production can be break-even above \$3/mscf and assuming an average netback price of \$7/mscf, projects are capable of yielding returns of 30% or more.** As such we believe that commercial scale production of coal bed methane should be feasible.
- **While below ground challenges are being addressed, there remain concerns around some of the above ground challenges.** Financing, partnership alignment, access to pipeline capacity and markets remain major obstacles to overcome for large scale CBM developments. The next 12 months will be a make-or-break period in this sector for Chinese majors and independents in particular as they push forward projects into commercial production.

Investment Conclusion

China has big plans for coal bed methane. China's CBM resources are (in theory) enormous at 1000TCF. NDRC has set an ambitious target to reach 5bcf/d by 2020 which would account for 25% of domestic supply. Although there are great expectations for CBM, reality has been somewhat different so far. After 10 years of exploration and appraisal, CBM production remains less than 100mmsc/d. Are things really about

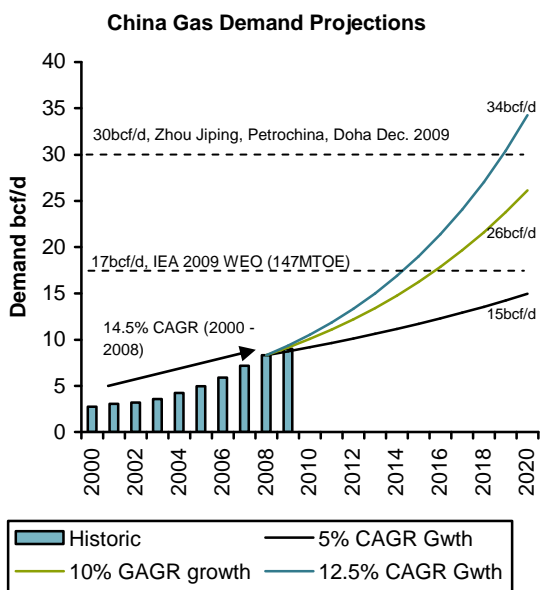
to change? There are three reasons we think so. Firstly, E&P companies appear to have got the technology right. After years of trial and error it is becoming clear that horizontal fraced wells are the right technology which will allow commercial scale gas production. Secondly, gas prices are on the rise. Coal bed methane prices are unregulated and through innovative CNG sales strategies and local industrial demand we believe wellhead netbacks can reach prices of \$7/mmbtu. Thirdly, Petrochina are starting to make development of CBM a priority. With the acquisition of Australia's Arrow Energy and restructuring of CBM licenses in China, Petrochina is publicly committed to a 10 fold increase in CBM production over the next 10 years.

Although smaller independent E&P companies operating in China offer the most direct exposure to coal bed methane, there remain issues of financing and market access for large scale developments. The next 12 months will be critical for these companies as they seek to move from the exploration to development phase. In the long run, Petrochina will be the largest CBM producer in China. We continue to believe that gas price re-valuation is inevitable and that Petrochina's gas portfolio is under-appreciated by investors in terms of both upstream growth potential and value of their midstream gas infrastructure network. We maintain an outperform rating on PetroChina with a price target of HKD12.50.

Details

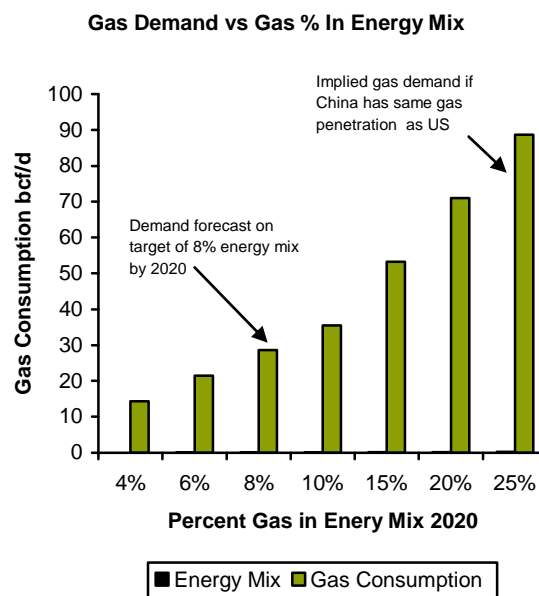
China's gas market potential is enormous – but what about supply? Over the next 10 years Chinese gas demand will increase by 200% at an annual compounded growth rate of 10% to 15% to reach a total annual demand of close to 300bcm (30bcf/d) by 2020 (**Exhibit 1**). Overall we expect gas to reach about 8% of the energy mix by then which although is a significant increase from current levels is still low relative to international standards such as the US where gas accounts for 25% of the energy mix (**Exhibit 2**).

Exhibit 1
China's gas market is set to grow at CAGRs of 10%-15% over the next 10 years



Source: BP Statistical Review, Bernstein estimates

Exhibit 2
We expect gas to reach c.8% of the overall energy mix in China by 2020



Source: BP Statistical Review, Bernstein estimates

While demand growth is understood, the controversy is where gas supply will come from to meet this demand growth. In recent years the focus has been on going overseas to secure imports. Chinese companies have been actively snapping up LNG contracts in Qatar and Australia. Total contracted LNG now stands at

over 30mtpa. In addition, Petrochina has built the world's longest pipeline from Turkmenistan to Shanghai to supply 4bcf/d from Central Asia to fast growth markets in Eastern China.

Before more imports are added to the growing list, aren't we forgetting something? What about the natural gas resources in China's own back yard? As experience from the US has taught us, the cost of unconventional gas can be cheaper than natural gas imports. China's policy makers are starting to understand the importance of this question given the unconventional gas revolution which has taken place in the US. In this research note we ask could China be the same.

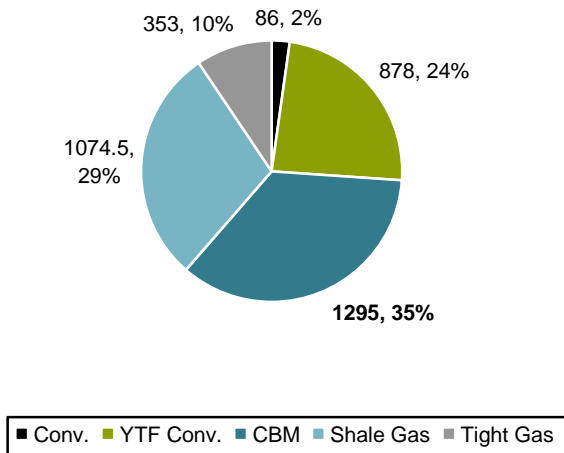
China's Coal Bed Methane Potential

The first question to ask is "does China have any unconventional gas?" On paper a lot, although how much of this can be produced economically is uncertain. According to China's geologists current proven conventional gas reserves represent 2% of China's total gas resource base. While there is more conventional gas yet to find, three quarters of China's gas reserves base is thought to consist of unconventional gas. Of the unconventional resource base, coal bed methane is the most significant, with total estimated reserves of 1200TCF (**Exhibit 3**). While the US is more about shale gas, China could be more about coal bed methane.

Although these estimates should be taken with a pinch of salt, there can be no dispute that China has an enormous coal reserve base which should underpin a large resource base in coal bed methane. China's estimated coal bed methane reserves are similar to that of the US and Australia, which (other than Russia) have similarly large coal reserves (**Exhibit 5**). With most of the coal resource in central China (Ordos and Qinshui) and the western (Junggar, Tarim) basins (**Exhibit 4**) the question for China is can this resource be developed commercially?

Exhibit 3
Coal Bed Methane Accounts for a third of China's undeveloped resource base

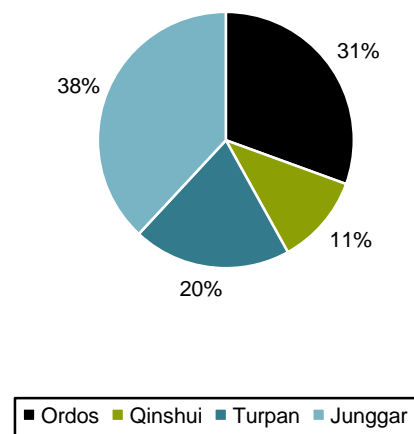
China Gas Reserves by Type (Total = 3,687 TCF)



Source: BP Stat. Review, Shale Gas in China; Liu 2008; Coal Bed Methane Exploration in China, Qiu 2009

Exhibit 4
Ordos and Qinshui account for a third of China's CBM

Distribution of Recoverable CBM Reserves (TCF)

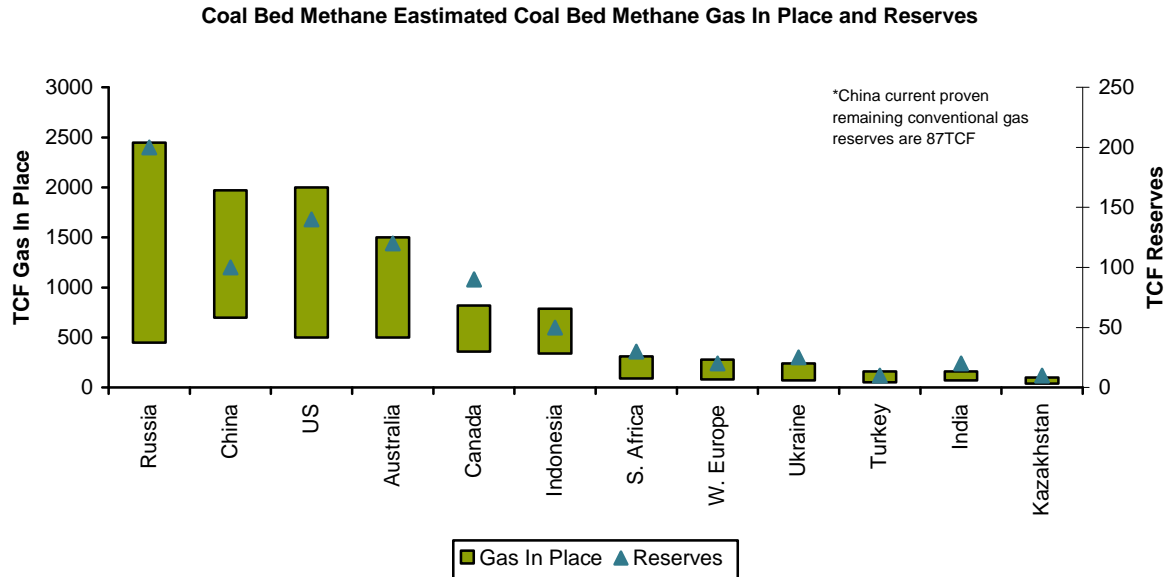


Source: Coal Bed Methane Exploration in China, Qiu 2009

By analogy with the US, it is clear that China has a way to go. The US currently has 20TCF of proven coal bed methane reserves which have increased significantly over the past 20 years as new basins have been drilled up (**Exhibit 6**). Coal bed methane production is around 5bcf/d (**Exhibit 7**), which is less than 10% of

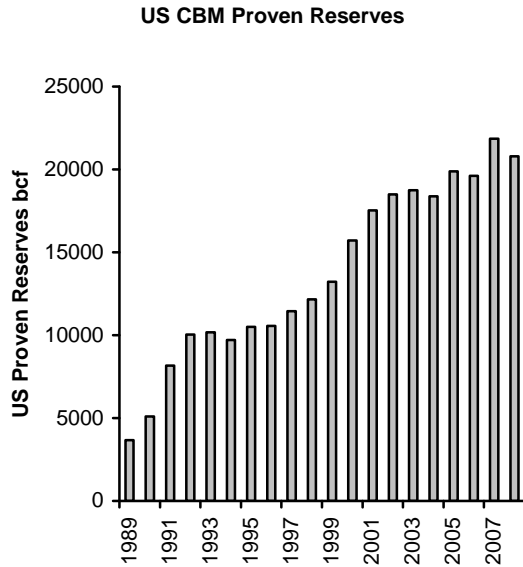
total US production but equivalent to over 50% of China's total current natural gas demand. While the potential looks promising the reality is that coal bed methane production over the past 10 years has been a long and painful experience for most companies as they have struggled to achieve commercial gas production rates. This may be about to change however with renewed government focus on unconventional gas and the ambitious production plans ahead for coal bed methane.

Exhibit 5
China has similar coal bed methane reserves to the US and Australia



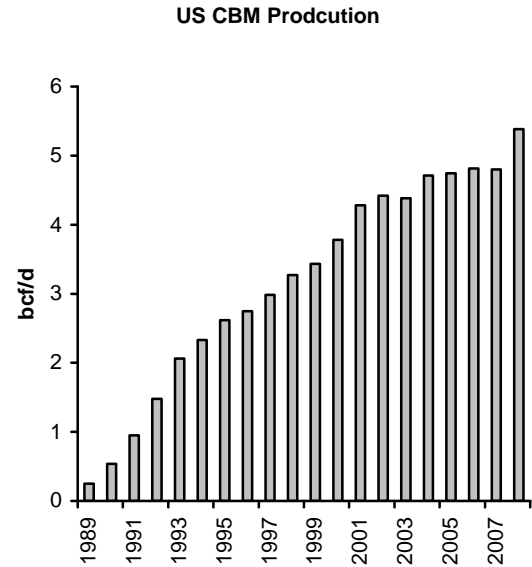
Source: Advanced Resources International

Exhibit 6
The US currently has 20TCF of proven reserves



Source: EIA

Exhibit 7
CBM production is around 5bcf/d. Equal to over 50% of China's demand

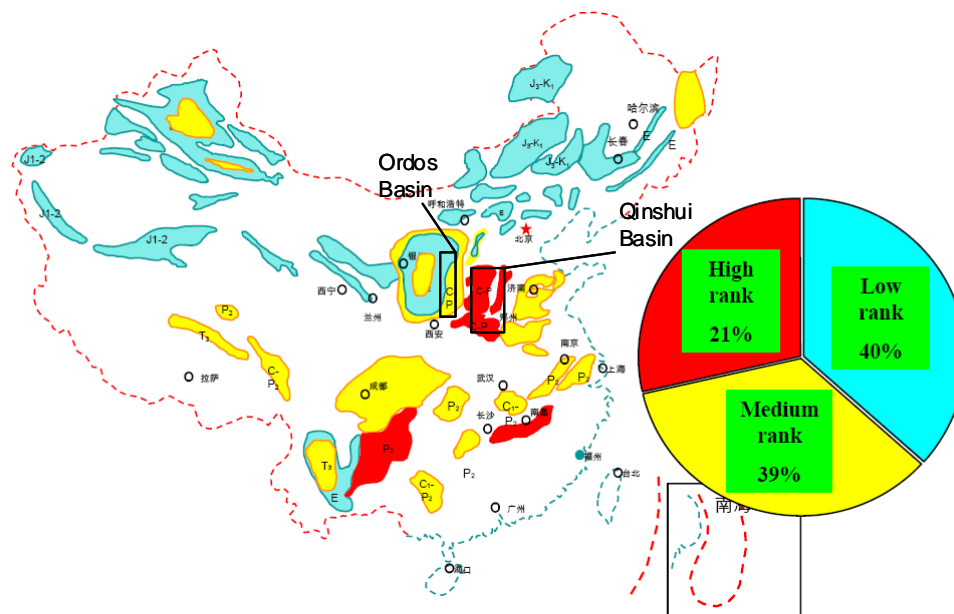


Source: EIA

China's Coal Basins

With over 100billion tons of proven coal reserves, China clearly has a lot of coal. The key coal producing basins are the Ordos and Qinshui basins in central China (**Exhibit 8**). While the Ordos Basin is a low to medium rank coal the Qinshui basin is a high maturity anthracite coal. Other major coal basins are in the west in the Tarim and Junggar basins of Xinjiang, Inner Mongolia and to the south in Yunnan and Sichuan. With the exception of Yunnan most of the other coals are medium to low grade in thermal maturity.

Exhibit 8
The main coal bed methane basins of China



Source: CUCBM

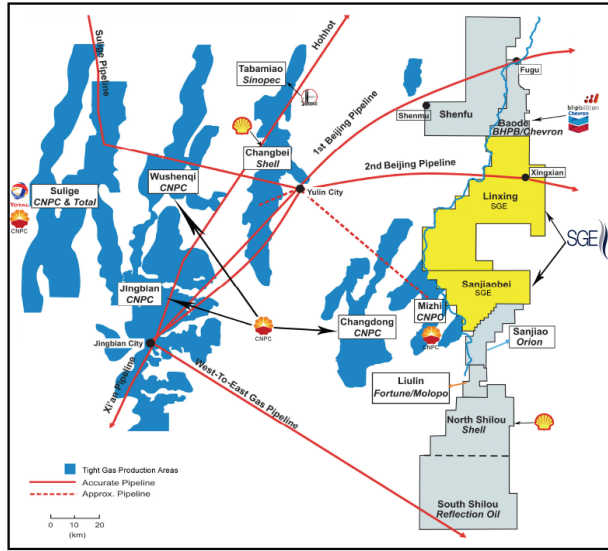
The Ordos Basin – Where is the Sweet Spot?

The Ordos basin is one of the largest sedimentary basins in China and home to China's largest tight gas fields such as Jingbian and Sulige. Coals within the Qinshui are Permo-Carboniferous in age and are medium rank in terms of their thermal maturity.

The Carboniferous Taiyuan formation is the main coal bearing formation which contains over 7 major coal seams. The main coal seams are #8 and #9 (**Exhibit 10**). Coal seam #8 is the most important and about 3 to 10 meters thick. While the base of the #8 unit is shale, the top of the coal seam is overlain by limestone which can also act as an aquifer in places. This is not ideal given the importance of hydraulic isolation of the coal seam and de-pressurization which is key for gas production given the under-saturated nature of these coals. The overlying Shanxi formation contains 4 to 6 major coal seams of which #3, #4 and #5 are relatively thick and continuous. Within the #8 coal seam there are areas of overpressure which is supportive of gas production. Cleats and fractures are present which can enhance permeability in some areas, although the overall permeability in the coal averages between 1 to 10md.

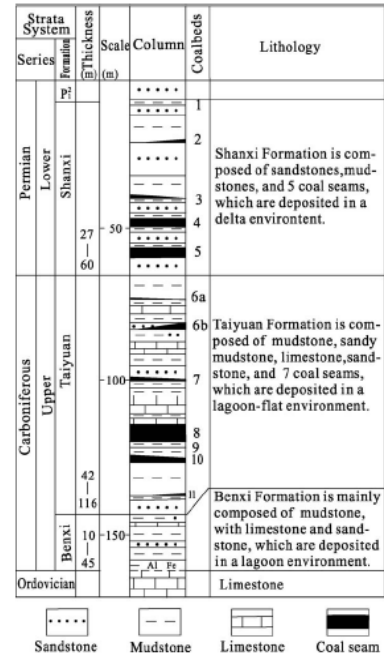
The acreage which has been licensed out is located to the east of the basin where the coals sit at a depth of between 300 and 1000m which is the ideal depth window for coal bed methane development and production (**Exhibit 9**). Further to the west the coal dips steeply away and is outside the limit of coal bed methane production (**Exhibit 11**). The blocks under license trend in a north south orientation along the margin of the basin. Given the distribution key parameters (coal thickness, overpressure, permeability) within the basin, our understanding is that sweet spot is somewhere close to the Sanjiao and Liulin blocks operated by Orion and Fortune respectively.

Exhibit 9
Ordos basin licensee blocks



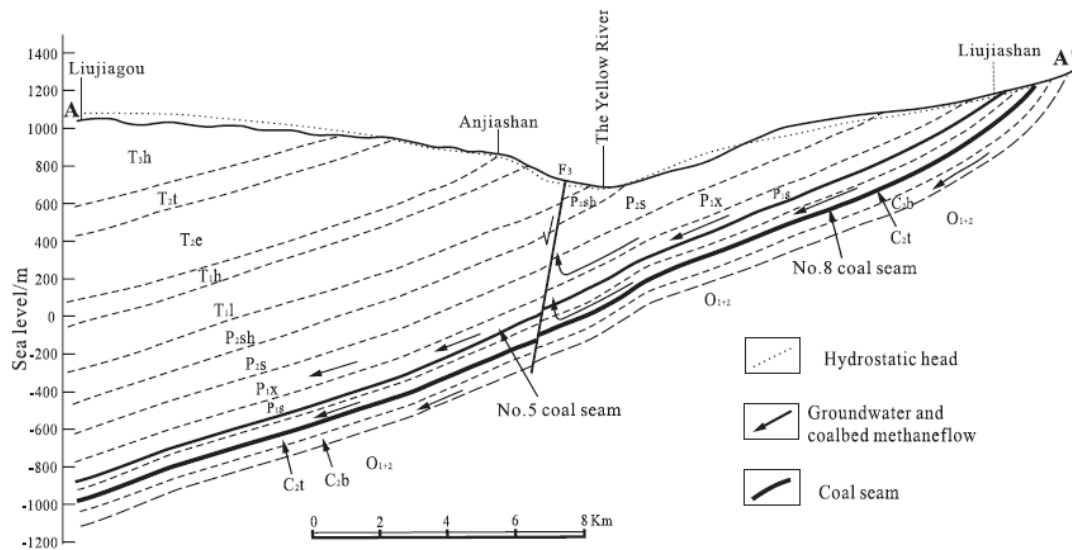
Source: SGE Corporate Report

Exhibit 10
Geological log of the Ordos basin



Source: Su, Zhang and Zhang, Coal Geology

Exhibit 11
Geological Cross Section Across the Ordos Basin



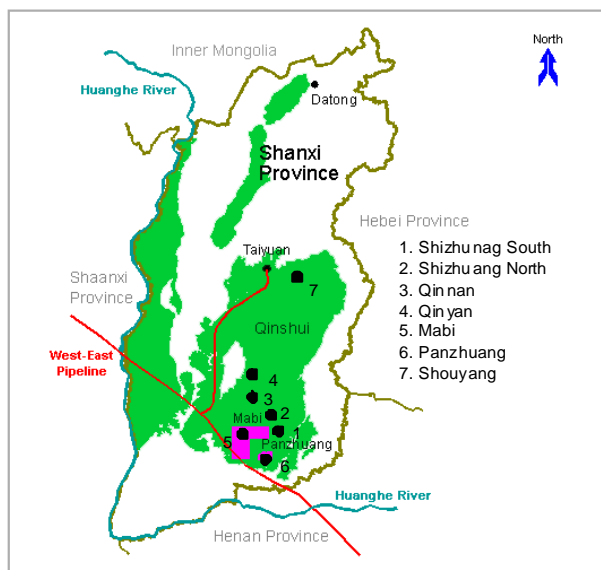
Source: Su, Zhang and Zhang, Coal Geology

Qinshui Basin – China's Anthracite CBM Play

The Qinshui basin the best know coal bed methane basin in China on account of the exceptionally high gas contents which can literally cause coal mines to "explode". Most of the blocks are located in the southern part of the basin where the gas content of the coals is generally higher. The permeability of the coals is generally similar to the Ordos basin at between 1md to 10md, although the Shouyang block in the north of the basin is known to contain coals which offer fracture permeability of greater than 100md. Many of the cleats or fractures within the coal are filled with a secondary cement (calcite) which does not help overall permeability. Coals in the Qinshui basin are anthracite grade which is the highest grade of thermal maturity. While this creates the high gas content the coal absorption capacity is high and most of the coals remain under-saturated with saturation levels of 80% meaning that they need to be de-pressurized before they can be produced. This can lead to significant time being required for de-watering of coals.

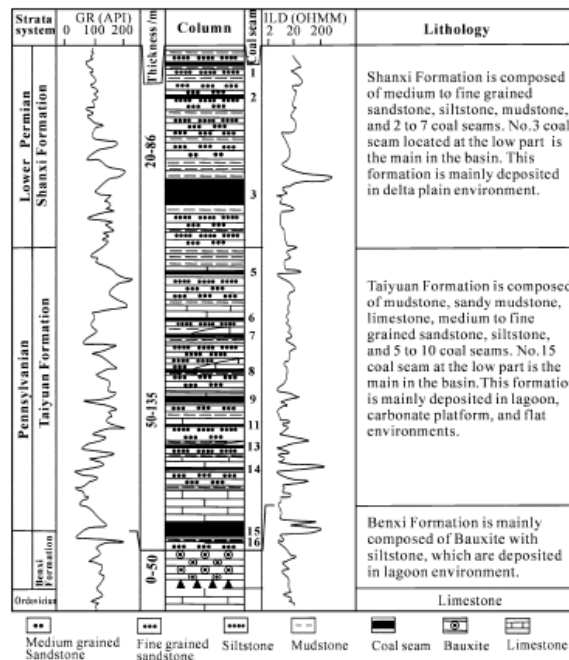
Like the Ordos basin the key formations are the Carboniferous Taiyuan formation and the Shanxi formation of the lower Permian. The key coal seam in the Taiyuan in the Qinshui basin is #15 which has a thickness of 1 – 15m (**Exhibit 13**). As in the Ordos basin, this coal seam is overlain by a limestone formation which can carry an aquifer and does not help to hydraulic isolation of the reservoir. Across the basin the #15 coal seam lies at about 700m depth which close to is optimal for CBM production. Within the Shanxi formation, the #3 coal is the key formation and 20m to 50m shallower than #15 seam. The Panzhuang block (AAGI) and South Shizhuang block (GDG) are generally the most favorable within the basin as these areas are slightly over-pressured, have the highest gas contents and are separated from the main aquifer within the basin which reduces water influx from the overlying limestone formation (**Exhibit 12**).

Exhibit 12
Map of the Qinshui Basin. Most blocks to the south



Source: AAGI Corporate Report (modified)

Exhibit 13
Geological log of the Qinshui Basin



Source: Su et. al. Coal Geology

How do the Chinese Coals Compare with US and Australia

Although China has large coal bed methane reserves how do the quality of the coals compare with other regions? The US is the world's largest producer of coal bed methane. Of the US basins, the San Juan basin is the most prolific with the Powder River and Black Warrior basins among some of the other well known

producing regions. In Australia, the key basins are in Queensland in the Bowen and Surat basins which will provide natural gas for the CBM to LNG projects which are currently being planned. A comparison between the coals from these key basins with the Qinshui Basin in China is shown in (Exhibit 14).

The gas content, coal thickness and the coal storage capacity are key drivers of coal bed methane resources and reserves. Thick coals with high gas contents provide the richest concentrations of gas per km2. In contrast, the principal drivers of production from coals are the permeability and the presence of fractures or cleats which enhance permeability. The degree of gas saturation is also important. Until saturation point is reached, no matter what the gas content, coals will produce water over gas.

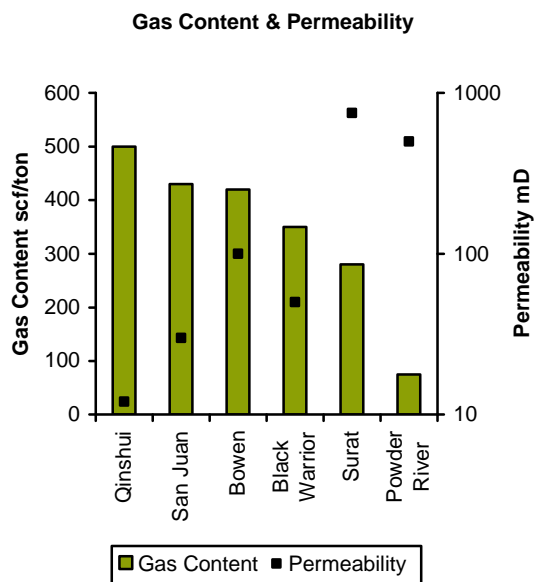
Exhibit 14
Comparison with the US and Australian Coal Basins

Country	US	US	US	Australia	Australia	China
Basin	San Juan	Powder River	Black Warrior	Bowen	Surat	Qinshui
Net Coal thickness (ft)	70	75	15	25	70	20
Gas Contents scf/ton	430	75	350	420	280	500
Permeability mD	30	500	50	100	750	10
Plateau Rate mmscf/d	2.0	0.25	0.1	1.2	2.2	0.1
Reserves Per Well (bcf)	8.0	1.0	0.5	5.0	2.8	0.3
Formation	Cretaceous	Paleocene	Carboniferous	Permian	Jurassic	Carb/Permian
Coal Type	Subbituminous	Subbituminous	Subbituminous	Subbituminous	Subbituminous	Anthracite

Source: Bernstein Est.

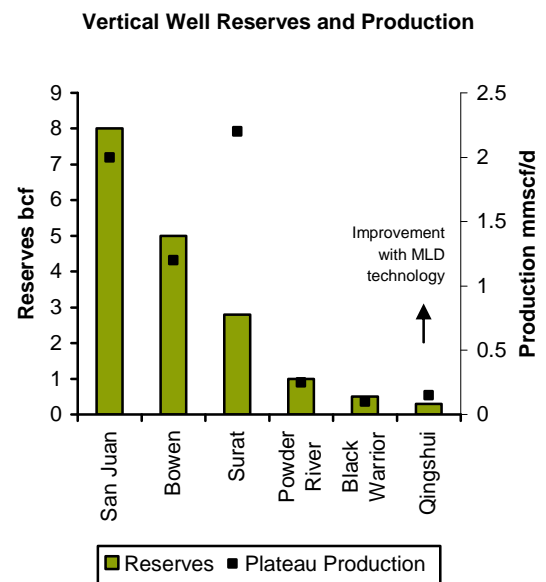
The Qinshui coals stand out as having among the highest gas content of any coals in our global screen, even higher than the prolific San Juan basin. Unfortunately however they are under saturated and low in permeability relative to almost all other prolific coal bed methane basins (Exhibit 15 and Exhibit 16).

Exhibit 15
Gas Content and Permeability of International CBM Basins



Source: Bernstein Est.

Exhibit 16
Flow rates and reserves of CBM basins



Source: Bernstein Est.

Although the Far east Energy Company (FEEC) have reported permeability in 100md range in the Shouyang block, most coals in the Qinshui basin are around 10md or less. By comparison, most other

prolific basins have coals with permeability in the 10-100md range or over 500mD such as in the Powder River or Surat basins in Australia. As result the deliverability and reserves recovery per well for vertical coal bed methane wells in the Qinshui basin are low compared to other regions. San Juan which has the highest per well rates and recoveries has exceptional flow rates because the coals are over-pressured, thick and have high gas content with high gas saturations.

CBM Licensing in China

China started licensing out coal bed methane blocks in the late 1990's. This was done to attract international technology and capital to an area where there was clearly an opportunity but little experience within Chinese companies to exploit. In the first wave of CBM development, US majors were the major acquirers of licenses. Conoco, Philips, Arco and Texaco were all key holders of acreage within the Ordos and Qinshui basins. Initial tests proved disappointing however as wells de-watered slowly and gas production was relatively small. Given the low demand for gas within the region and low gas prices, economic development of the coal seams was not deemed possible.

As a result, many companies sold their rights to production sharing contracts to smaller companies, many of which had experience or management with coal bed methane in North America. As a result, most of the foreign companies participating in China CBM today tend to be small foreign independents some of which acquired directly or picked up acreage relinquished by the majors. Shell and Conoco are the notable majors who remain in coal bed methane in China and still have an active interest. A summary of the key acreage holders in China is shown in **Exhibit 17**

Exhibit 17

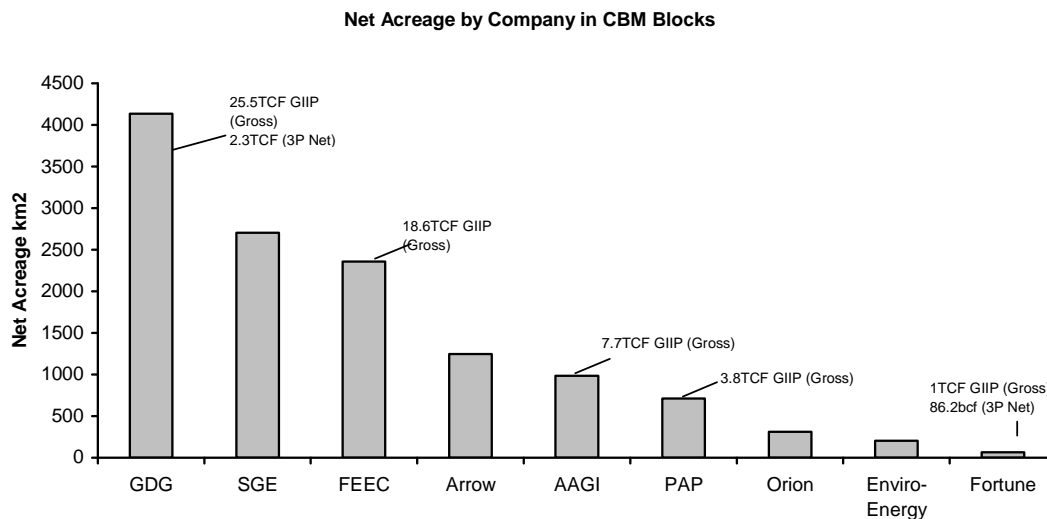
License Blocks Issued In China with Foreign Partners

Block	Location	km2 PSC Area	Reserve bn m3	Signing	Foreign Partner	Equity	CUCBM/ PTR	Basin
1	Haibei	Anhui	2663	60	Jun-98	CVX		Anhui
2	Sanjiao	Shanxi	448	63.5	Jun-98	Orion	70	Ordos
3	Sanjiao Bei	Shanxi	1126	55	Jun-98	SGE	49	Ordos
4	Shilou	Shanxi	3602	175	Jun-98	RDS/Reflection		Ordos
5	Linxing	Shanxi	3325	300	Jun-98	SGE	64.75	Ordos
6	Fengcheng	Jiangxi	1541	37	Aug-99	GDG	49	Ordos
7	Liulin	Shanxi	198	30	Nov-99	Fortune Oil/Arrow	32.5/17.5	Ordos
8	Zhungeer	Inner Mongolia	2817	400	Nov-00	CVX?		N. Ordos
9	Baode	Shanxi	1079	120	Nov-00	CVX?		Ordos
10	Shenfu	Shaanxi	3001	600	Nov-00	CVX?	50	Ordos
11	Hengshanbao	Ningxia	1807	230	Jan-01	Virgin		W. Ordos
12	Qingshui	Shanxi	2317	450	Apr-02	COP		Qinshui
13	Shouyang	Shanxi	1963	230	Jul-02	FEEC/COP	66.5/3.5	Qinshui
14	Louchang, Enhong	Yunnan	1072	140	Dec-02	FEEC	60	Yunnan
15	Qinyuan	Shanxi	3665	550	Mar-03	GDG	60	Qinshui
16	Panxie East	Anhui	584	20	Jan-03	GDG	60	Anhui
17	Shizhuang South	Shanxi	455	90	Jan-03	GDG	60	Qinshui
18	Shizhuang North	Shanxi	375	75	Jan-03	GDG	60	Qinshui
19	Jincheng	Shanxi	151	28	Mar-03	AAGI	50	Qinshui
20	Huangshi	Hubei	305	5	Oct-03	Gladstone		Hubei
21	Mabi	Shanxi	1381	240	Jul-04	AAGI	60	Qinshui
22	Baotianqingshan	Guizhou	947	160	Sep-05	GDG	60	Guizhou
23	Liuhuanggou	Xinjiang	654	35	Dec-05	Enviro Energy (TWE)	47	Xinjiang
24	Shilounan	Shanxi	1011	189	Feb-06	Reflection	60	Ordos
25	Suzhou	Xinjiang	856	120	Mar-06	Ivana Venture	65	Xinjiang
26	Qinnan	Shanxi	2317	320	Jul-02	FEEC, Arrow, COP	17.7/52.3/5	Qinshui
27	Panzhuang	Shanxi	157	20	Mar-03	AAGI	51	Qinshui
28	Shiloubei	Shanxi	2591	n/d	Nov-05	RDS, Verona	55/5	Ordos
29	Zijinshan	Shanxi	708	109	Apr-08	PAP	100	Ordos
30	Hencheng	Shaanxi	n/d	n/d	Mar-07	Longmen Huifeng	60	Ordos

Source: CUCBM, Bernstein Est.

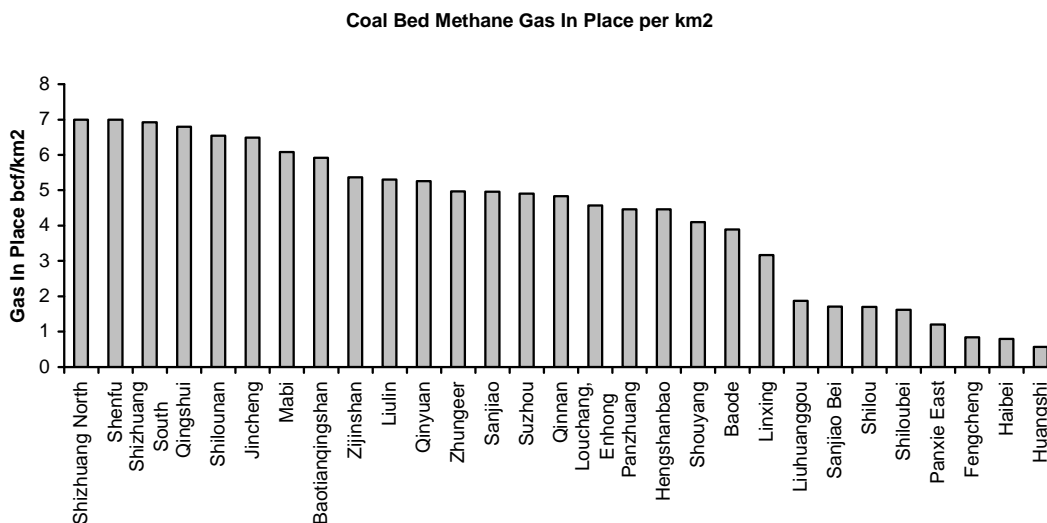
Among the independents, Green Dragon Gas, Sino Energy Holding, Far East Energy have the largest acreage positions, mostly in the Qinshui and Ordos basins (**Exhibit 18**). Green Dragon Gas has the largest gross gas in place of any independent E&P with over 25TCF in place in their acreage and with net 3P reserves of 2.3TCF. The average gas in place for each of the blocks varies from 7bcf/km² to less than 1bcf/km² (**Exhibit 19**). The average in the Ordos and Qinshui basins is close to 5 to 6bcf/km². With an average recovery factor of 50% to 60%, 3P reserves per km² are between 3 to 4bcf/km².

Exhibit 18
Net Acreage and Reserves of CBM Companies



Source: Bernstein Est.

Exhibit 19
Gas In Place Per km²



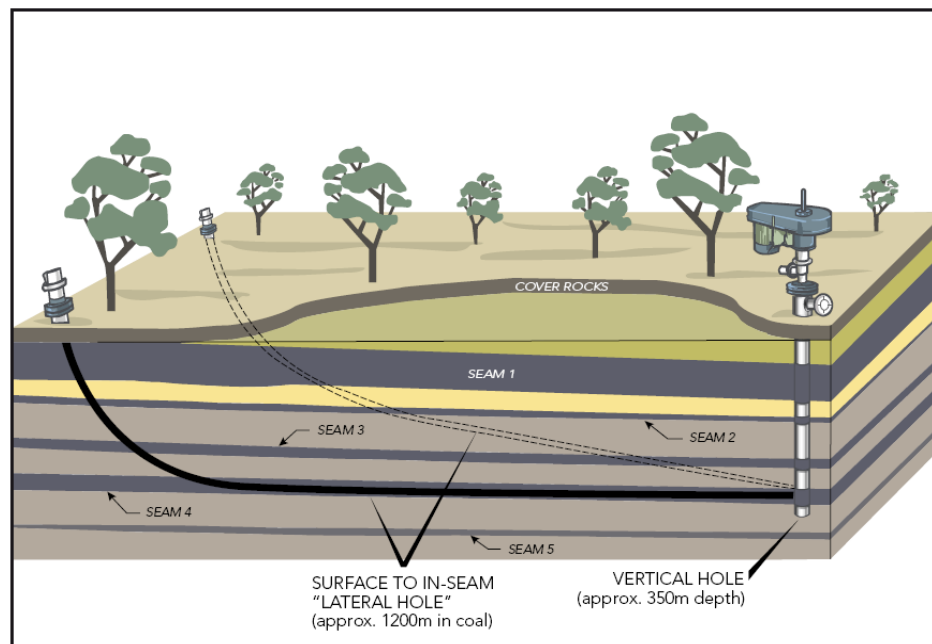
Source: Bernstein Est.

Economics of Coal Bed Methane – Will It Work?

The development of coal bed methane in China will be different from other major producing basins in North America and Australia. Coal seams in China are generally thinner and lower in permeability than the prolific basins of Australia and the US. More over, given the limestone cap-rock to the key producing coal seams, hydraulic separation can be a problem and means that producing wells need to produce from as far from the aquifer carrying beds as possible.

As a result the most effective way to develop Chinese coal bed methane is through horizontal wells (with multiple well bores) which are fraced to enhance the permeability of the coal and maximize contact with the coal formation. Independent E&P companies have realized this and have pioneered the development of horizontal wells which run for 1200m in the reservoir with multilateral wells off the main well bore. These wells are twinned with a vertical well which is used to lift water from the well bore to accelerate de-watering and de-pressurization of the reservoir to enable free gas to flow within the reservoir (**Exhibit 20**).

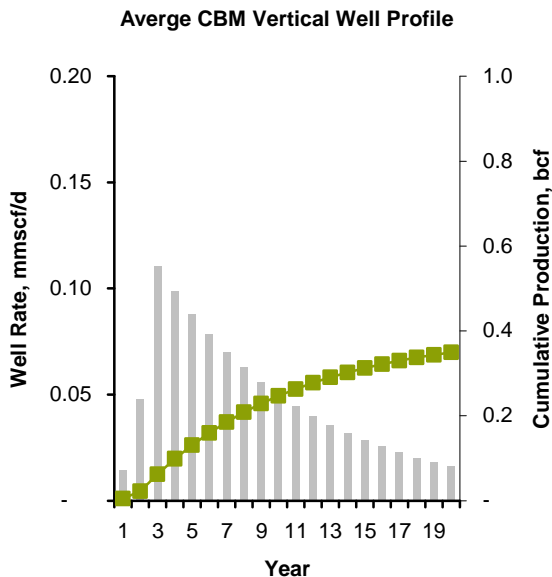
Exhibit 20
Surface to Seam Drilling Technique



Source: CH4

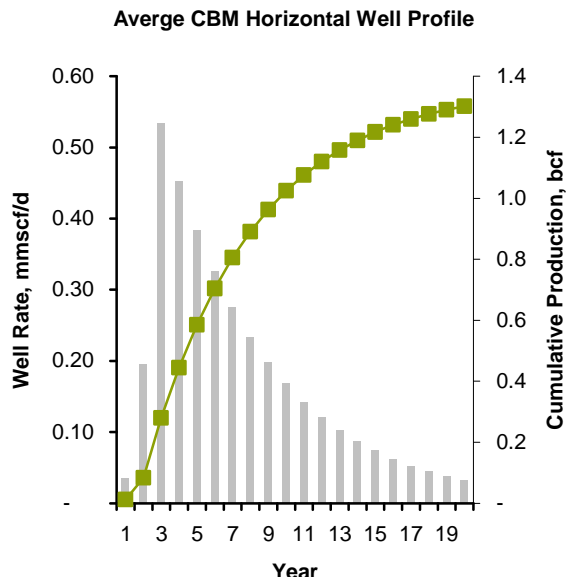
This technique has led to a significant improvement in well productivity and reserves recovery. Analysis of published data indicates that the average vertical CBM well produces 50 to 100mscf/d and can recover 0.3bcf of gas. Horizontal wells drilled as described above can produce over 5 to 10 times more gas with productivity up to 2mmscf/d in some cases and recoveries of 1 to 3bcf (**Exhibit 21** and **Exhibit 22**).

Exhibit 21
A single vertical well profile



Source: Bernstein Est

Exhibit 22
A single horizontal well profile



Source: Bernstein Est.

While horizontal wells are significantly higher in cost, the higher flow rates and reserves recovery makes these wells better investments. Given that we have yet to see a large scale CBM development in China, overall cost estimates remain uncertain. We have assumed the following development scenario which we believe is realistic. Our assumptions are based on a block developed using vertical wells spaced at 100 acres and horizontal wells spaced at 200 acres. The cost of a horizontal and vertical well is assumed to be \$1.5MM and \$0.3MM respectively (including associated surface facilities, flow lines and handling).

Exhibit 23
Key assumptions used in our CBM model

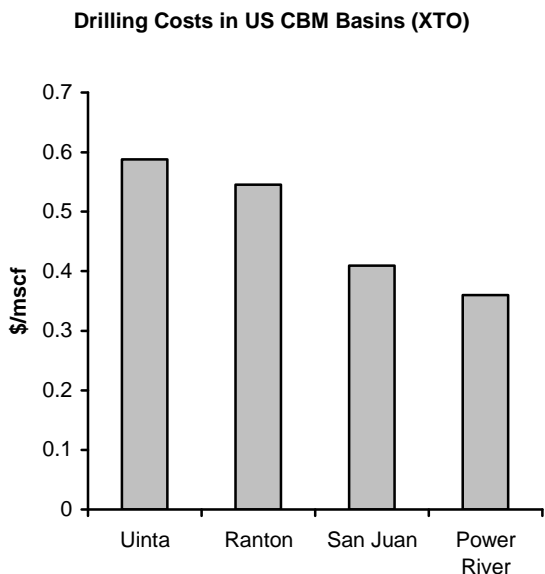
Key Assumptions						
Block Parameters			Horizontal	Vertical		
Block area	km2	462	Well spacing	acres	200	100
GIIP	bcf/km2	4.55	No. of wells	#	550	1100
GIIP	bcf	2,102	Costs per well*	\$MM	1.5	0.3
Recoverable reserves	bcf	1,107	Reserves per well	bcf	1.3	0.4
Recovery factor	%	53%	Peak rate per well	mmscf/d	0.53	0.11
			Ramp up period	years	2	2
Economic parameters						
Wellhead gas price	\$/mscf	7.0	F&D costs	\$/mscf	1.0	
Gas price inflation	%	3% p.a.	Tax rate	%	25%	
Opex	\$/mscf	0.5	Discount rate	%	10%	
Opex inflation	%	3% p.a.				

*Costs include drilling, de-watering, completion and surface facility costs

Source: Bernstein Est.

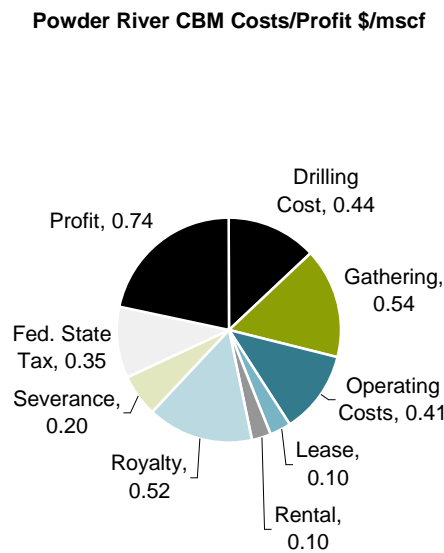
As a check on the capital estimates, we have compared these to North American CBM projects. Using data from XTO (now XOM) average drilling development costs in CBM basins is around \$0.50/mscf (**Exhibit 24**). This is only part of the cost however, including gas gathering costs (flow lines, water separation and compression) which adds a further \$0.50/mscf the minimum development costs are around \$1/mscf which is in line with our estimates (**Exhibit 25**). Operating costs are close to \$0.40/mscf which assumes surface evaporation ponds for water disposal with out the need for secondary re-injection.

Exhibit 24
Drilling Costs of US CBM Wells



Source: XTO Corporate Presentation, XTO

Exhibit 25
All in Costs for Powder River development

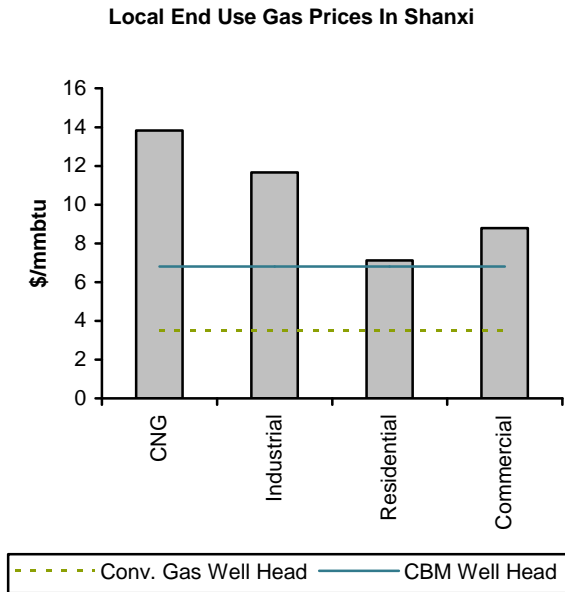


Source: Powder River Coal Bed Economics

Pricing of CBM in china is not regulated unlike conventional gas. No VAT is applied to coal bed methane sales. In addition the government provides a 0.2RMB/m² subsidy (\$0.8/mmbtu) which is supplemented by a local subsidy in Shanxi of 0.05RMB/m³ (\$0.2.mmbtu) to encourage development.

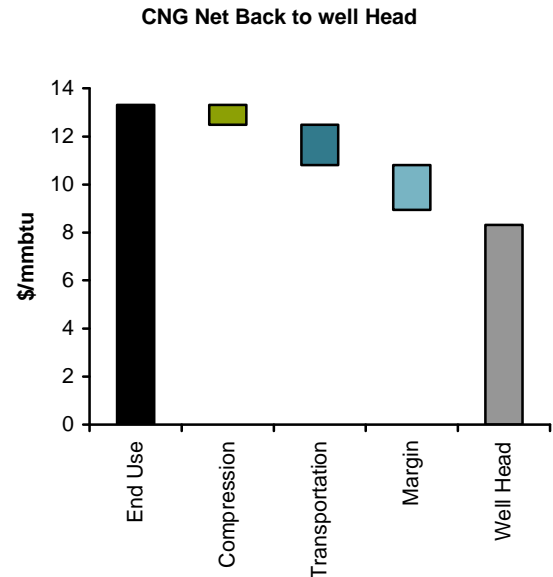
Over recent years the local gas price in Shanxi and neighboring provinces has been increasing. City gate prices are around \$8/mmbtu while industrial pricing can be as high as \$12/mmbtu (close to fuel oil parity). Sales to CNG users have been a popular way to monetize CBM gas given the lack on infrastructure connections. CNG retail prices are high at \$13/mmbtu which gives a net back of \$7 to \$8/mmbtu at the wellhead. For the purpose of this analysis we have assumed an average wellhead price of \$7/mmbtu real (escalating at 3%). This price is double the regulated conventional gas price in Ordos.

Exhibit 26
End Use Gas Prices in China



Source: Green Dragon Gas Corporate Report, Bernstein Est

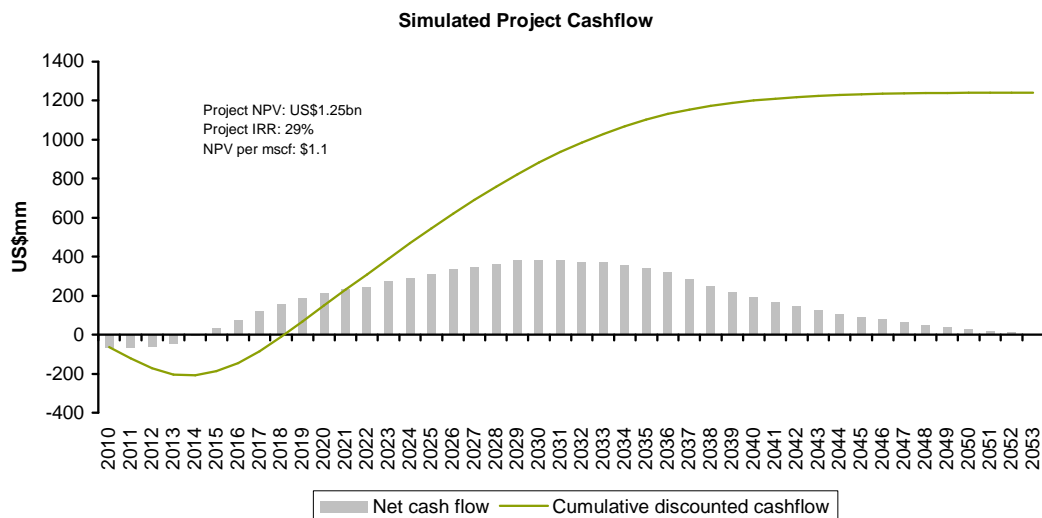
Exhibit 27
CNG Netbacks to Wellhead



Source: Bernstein Est

Using cost estimates and our gas price assumptions above, we have developed an economic model to arrive at our estimate of the value of gas from a CBM development. Using our base case assumptions, we calculate a project NPV of US\$1.25bn with an IRR at 29% which allows us to conclude that CBM developments should be economic (**Exhibit 28**).

Exhibit 28
Using our base case assumptions, we calculate a project NPV of US\$1.25bn with an IRR at 29%



Source: Bernstein Est.

We estimate the present value of a CBM development to be around \$1 to 1.5/mscf but could vary depending on final costs and gas price assumptions. The overall IRR should be 30% and a \$3 to \$4/mmbtu gas price (real) is required for a minimum IRR of 15%.

Exhibit 29
Present Value of CBM per mscf

		NPV per mscf, \$							
		Wellhead gas price, \$/mscf							
F&D costs, \$/mscf		3	4	5	6	7	8	9	10
	1.4	-0.1	0.2	0.4	0.7	1.0	1.2	1.5	1.7
	1.3	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.7
	1.2	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8
	1.1	0.1	0.3	0.6	0.8	1.1	1.3	1.6	1.8
	1.0	0.1	0.4	0.6	0.9	1.1	1.4	1.6	1.9
	0.9	0.2	0.4	0.7	0.9	1.2	1.4	1.7	1.9
	0.8	0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0
	0.7	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0
	0.6	0.3	0.6	0.8	1.1	1.3	1.6	1.8	2.1

Source: Bernstein Est

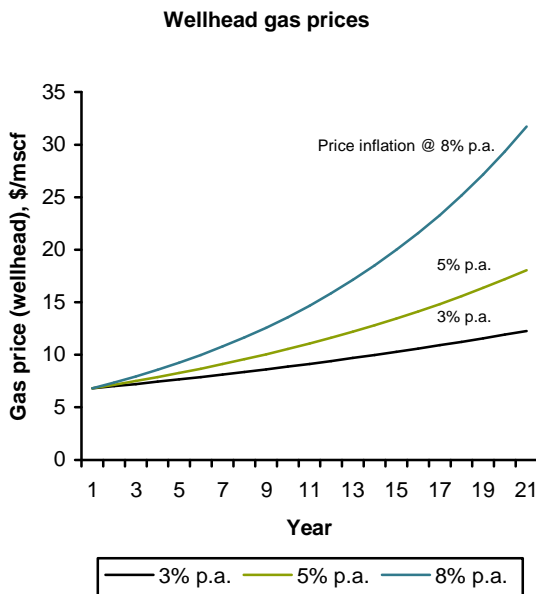
Exhibit 30
Project IRR of CBM developments

		Project IRR							
		Wellhead gas price, \$/mscf							
F&D costs, \$/mscf		3	4	5	6	7	8	9	10
	1.4	8%	13%	17%	20%	23%	26%	29%	31%
	1.3	9%	14%	18%	22%	25%	28%	30%	33%
	1.2	11%	15%	19%	23%	26%	29%	32%	35%
	1.1	12%	17%	21%	25%	28%	31%	34%	37%
	1.0	13%	18%	23%	27%	30.1%	33%	36%	39%
	0.9	15%	20%	25%	29%	32%	36%	39%	42%
	0.8	16%	22%	27%	31%	35%	39%	42%	45%
	0.7	19%	25%	30%	34%	39%	42%	46%	49%
	0.6	21%	28%	33%	38%	43%	46%	50%	54%

Source: Bernstein Est

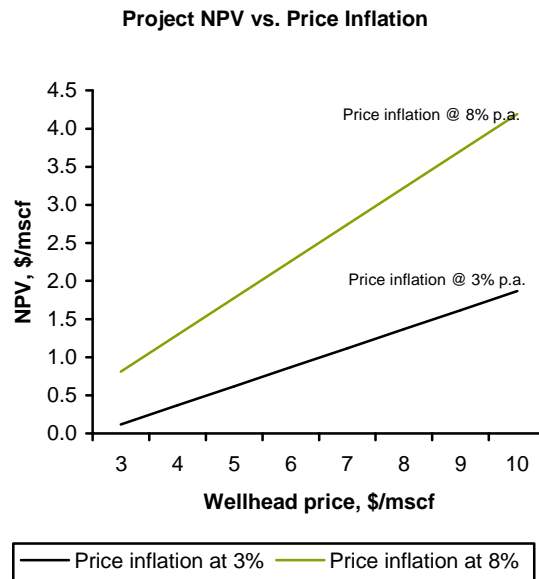
One of the greatest sensitivities to economic value is gas price inflation (Exhibit 31 and Exhibit 32). Although we expect regulated gas prices to increase significantly over the coming years, we do not expect unregulated gas prices to increase at a rate much beyond the rate of inflation. As such we believe that an escalator of 3% is more appropriate and is consistent with a long term oil/gas price ratio of around 10:1 which we believe is reasonable.

Exhibit 31
Gas price inflation assumption has a huge impact on long term gas prices...



Source: Bernstein Est

Exhibit 32
... and therefore project NPV



Source: Bernstein Est

Assessing the Value of Coal Bed Methane

How much is a coal bed methane project worth and how much should the market pay? Some of the independent E&P companies have published data on the estimated value of their reserves as carried out by Netherland Sewell and Associates Inc. (NSAI). NSAI evaluation of reserves is based on the discounted value of net revenues (revenues less capital and operating costs) and is not intended to be a net present value calculation. Nevertheless it gives a useful guide of the possible upstream value.

Using NSAI information, the value of CBM reserve ranges from \$4/mscf (**Exhibit 33**) to up to \$6/mscf in some reports. This is significantly higher than our estimates of \$1.1/mscf. We believe there are two factors driving this difference. Firstly, NSAI does not include corporate tax. We do, although there is the issue of historic costs which are carried by the operators during the exploration phase and should be reimbursed during the production phase helping to offset tax expenses. The other difference is the gas price escalation factor. If we used an 8% we would get a discounted value of \$3/mscf (post tax) (**Exhibit 32**) and close to \$4/mscf pre-tax. This is significantly higher than our assumption of 3%. Clearly the choice of escalator on gas price is a key assumption for economic assessment.

Exhibit 33
NSAI Estimated Value of 3P Reserves

Block	WI	km2 Area	bcf Gross GIIP	Net 1P bcf	Net 2P bcf	Net 3P bcf	3P bcf/km2	\$MM 3P NPV10	3P (NASI) \$ per mscf
Shizhuang South	60%	455	3341	32.9	232.4	1081.8	4.0	4336	4.01
Shizhuang North	60%	375	3602			1023.7	4.5	4015	3.92
Qinyuan	60%	1541	6886				0.0		
Fengcheng	49%	3665	4050		28.9	227.7	0.1	1001	4.39
Panxie East	60%	584	1124				0.0		
Guizhou	60%	946	3391				0.0		
Total		7566	22394	32.9	261.3	2333.2		9351	4.00

Source: Green Dragon Gas, Bernstein Est

The other window on valuation is through M&A deals (**Exhibit 34**). Although there have been several deals done over the past few year, there have been few with useful transaction metrics which can be used.

Exhibit 34
Acquisition Value of CBM Gas Reserves

Deal	Date	Terms	Total Cost \$MM	3P Reserves bcf
COP / Green Dragon Gas Farm In	Aug-09	COP option to GDG to acquire 50% share in 3 PSC licenses; Shizhuang South (1081bcf), Shizhuang North (1024bcf) and Qinyuan. COP will \$20MM initial payment, \$30MM of capex plus additional payment of \$120MM to acquire 50% share of GDG interest in licenses.	170	1052bcf (2105bcf x 50%)
Arrow / Fortune Oil Farm In	Dec-09	Arrow pays \$13.3MM to FTO for a 35% share in FLG which has 60% Working Interest in Liulin block (86.2bcf)	13.3	30.2 (86.2bcf x 35%)
Arrow / Far East Energy Company	Dec-09	Arrow pays \$10MM to FECC for a 75.25% working interest in FECC block Qinan	10.0	No 3P reserves

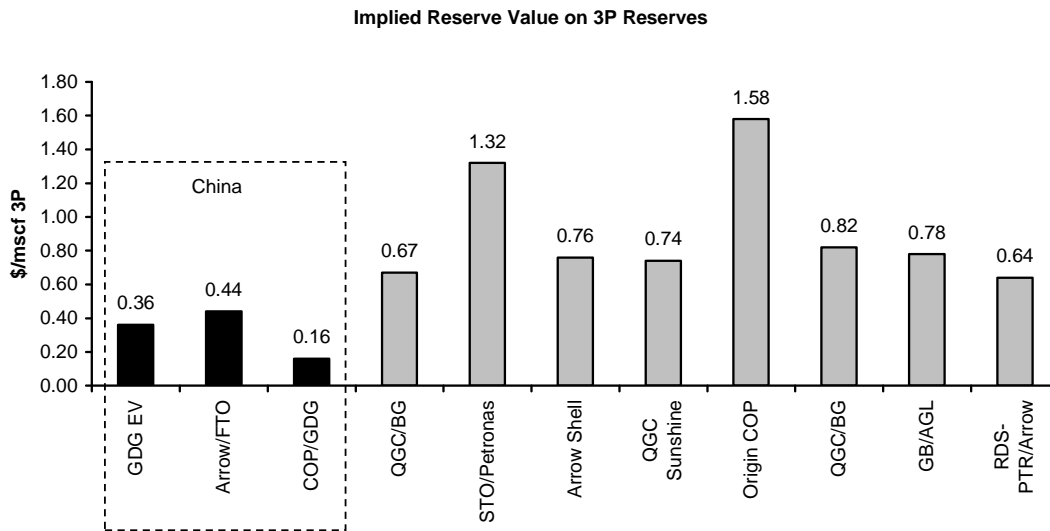
Source: Bernstein Est

Using these transaction values it is possible to derive a value which has been paid for these assets. We prefer to use 3P reserves as the most representative indication of reserve potential. From the Conoco option to farm in to Green Dragon acreage (if exercised), we estimate the price per 3P reserve is around \$0.16/mscf. With the Arrow farm into Fortune's Liulin block we estimate this to be around \$0.44/mscf on

3P reserves (although the Liulin has a large 2C resource base which has yet to be appraised and suggests significant uplift in 3P reserves is possible) (**Exhibit 35**).

These transaction values compare to the current value of Green Dragon Gas which assuming zero value for its down stream business would yield a value of \$0.36/mscf on 3P reserves. Note that this value is significantly lower than most of the other CBM reserves deals done in Australia which were between \$0.60/mscf to \$1.60/mscf. It is also lower than the purchase price of Arrow by Petrochina/Shell was around \$0.64/mscf.

Exhibit 35
Comparison of M&A transaction metrics

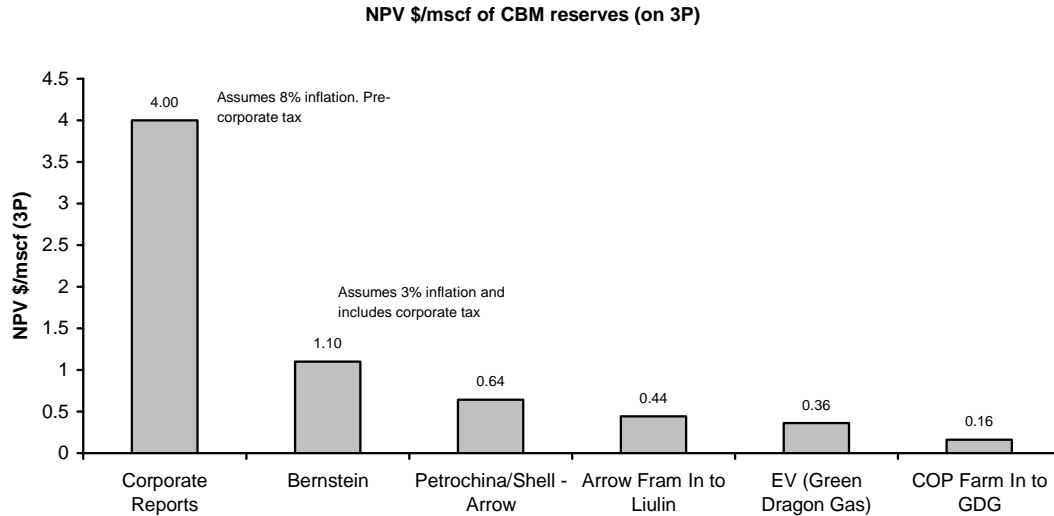


Source: Bernstein Est, Corporate Reports.

To summarize, while we believe that coal bed methane projects can be economic with the selection of the right well technology, there still remains a significant uncertainty in development costs and long term gas pricing to accurately place a value of these assets. While some estimates suggest the value of reserves could be as high as \$4/mscf, we find this to be too optimistic believing that \$1/mscf to \$1.50/mscf to be more realistic (**Exhibit 36**). This is however higher than the market is paying for these assets.

The best estimate of the market value for CBM is probably Green Dragon Gas which trades on \$0.36/mscf. Although some may say this is too high since it discounts the value of its downstream business, it also discounts the value from over 90% of its acreage which have no 3P reserves. It also does not include the potential impact of Conoco completing on its farm in which could cut 3P reserves by 50%. Assuming that Green Dragon EV is the underlying market value of the reserve base then it is implying a 30% to 40% chance of success of these reserves being developed, which is not an unreasonable assumption in our view.

Exhibit 36
Valuation Summary for CBM assets



Source: Bernstein Est

Risks to CBM Development

While we are optimistic on the future of coal bed methane in China, we believe that at most CBM will account for only 5% to 10% of the domestic supply mix by 2020. This would imply 1bcf/d to 2bcf/d and is still a significant increase from where we are today. Although there are a number of projects (AAGI, Green Dragon, Fortune Oil, Far East Energy) well advanced through pilot production and at the early stages of commercial production there remain some key above ground risks that investors should be aware of:-

Infrastructure/Market Access

To develop large scale coal bed methane projects requires market access at scale. While compressed natural gas or small scale liquefaction units may help to support small scale or early development schemes, we do not believe these are suitable for large scale development of CBM bocks in China. Ultimately CBM producers need to connect with pipelines to major markets. The good news is that most of the CBM blocks are proximal to major pipelines (Ordos to Beijing, WEP). The more difficult part is that Petrochina control access to most pipelines and has strong bargaining power in any gas off-take agreements.

Financing

Development of a 400km² block which contains 3P reserves of 3-4bcf/km² will require USD \$1.2bn to \$1.5bn assuming F&D costs of \$1/mcsf. Even if capex is phased over several years the costs will be significant for some of the smaller E&P's who are not rich in cash. As a result it seems likely that the independents will have to dilute their equity, raise capital through rights issues or develop at a much slower pace that currently envisioned.

Government Approvals

At present no CBM project with a foreign partner has (to our knowledge) been awarded approval of its ODP (development plan). While this may be matter of time, there remain uncertainties over what regulations or restrictions the government may put in place prior to the first developments being awarded. Moreover, some of the PSC's have requirements to complete the exploration and appraisal phase within 3-5

years of signing. If companies have been unable to deliver on this, there is a residual risk that extensions may not be approved.

Partnership Alignment

Since the decision by Petrochina to pull out of their joint venture with CUCBM, CBM blocks have been split between both companies. While this could be a positive, there remains a funding issue with CUCBM and whether it will be able to pay for its share of any development work program which could lead to project delays. There are also uncertainties around Petrochina's strategy and what blocks they want to develop first. Any development will need clear alignment with the designated Chinese partner to move forward.

Ways to Play the Sector

Within China, Green Dragon Gas and Far East Energy Company are the purest ways to play the coal bed methane theme (**Exhibit 37**). Green Dragon Gas is considerably larger than Far East Energy and also has a growing downstream gas segment. Although Petrochina will dominate this area in the long term, CBM will have little direct impact on their earnings over the next few years. Longer term however, the growth in CBM could be an important driver for gas growth within the company.

Fortune Oil and Enviro-Energy are also involved in coal bed methane, although this still represents only a small part of their business. While there are other companies involved some of these are privately held such as AAGI.

Exhibit 37

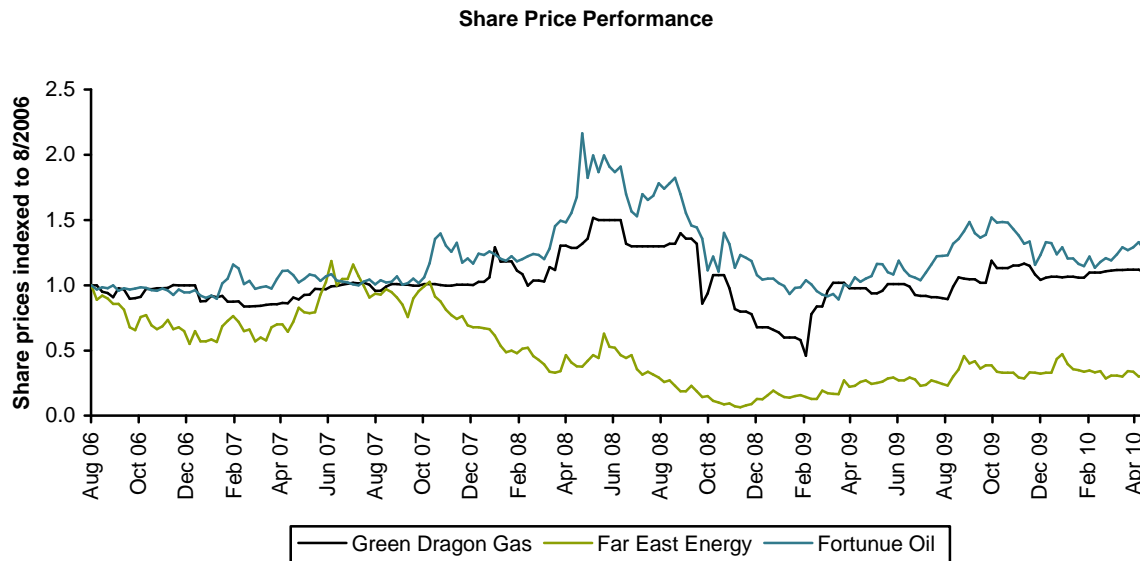
Independent Coal Bed Methane Companies

	Green Dragon Gas	Fortune Oil	Far East Energy	Enviro Energy
Bloomberg ticker	GDG LN	FTO LN	FEEC US	8182 HK
Exchange	London	London	US	Hong Kong
No. of shares, mm	121	1987	186	2432
Price, US\$	6.480	0.100	0.42	0.080
Market Cap, US\$mm	780.9	198.1	77.9	193.8
Net debt/(cash), US\$mm	-16.37	59.56	2.88	27.82
EV, US\$mm	764.5	257.6	80.8	221.6
3P Reserves bcf	2333.2	86.2	n/a	n/a

Source: Bloomberg

Over the last 3 years, Fortune Oil and Green Dragon shares have traded sideways, Far East Energy have declined as they have farmed out acreage to maintain cash flow. While we do not cover Green Dragon Gas, Fortune Oil or Arrow (soon to be Dart), these companies will be interesting to follow over the next 12 months as they ramp up drilling and seek government approval for the first large scale coal bed methane projects in China. If any of these companies are successful, it could lead to a re-rating in values across this sector.

Exhibit 38
Share Price Trends for CBM Companies in China



Source: Bloomberg

Summary

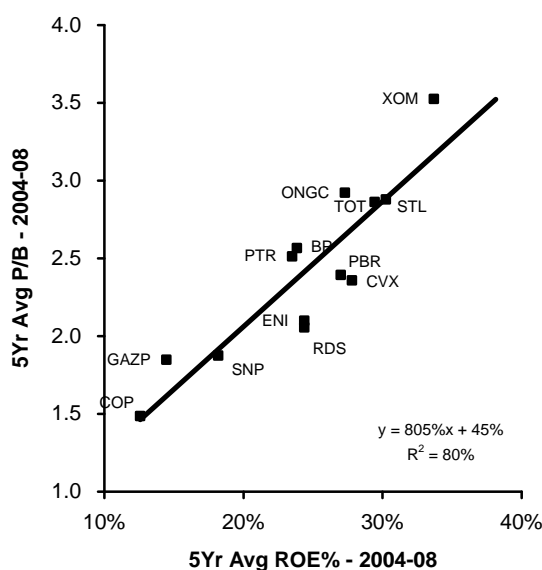
Coal bed methane will play an important role in China's gas future. Given that it represents a potentially enormous gas resource, there will be pressure to develop this resource from the government. While Chinese coal bed methane in the Ordos and Qinshui basin is not as good quality as the San Juan Basin or some of the basins in Eastern Australia, we believe that reserves can be economically produced through application of horizontal drilling. Over the next 12 months we believe that there will be significant progress in this area as full scale development plans are taken forward for approval and Petrochina moves forward with some large scale independent developments. While we see Petrochina as a long term winner, some of the smaller independent E&P companies could benefit also depending on solving some of the above ground challenges to CBM development.

Disclosure Appendix

Valuation Methodology

Our valuation methodology for Asia-Pacific large cap integrated oil and gas companies (PetroChina, Sinopec, ONGC and RIL) is based on the historically strong correlation between price to book ratio and return on equity (**Exhibit 39**). This relationship is based on average values for the past 5 years. Using this relationship we derive a regression co-efficient of 0.8. Target prices are calculated by applying our 2011E ROE estimates to derive our target P/B multiples which we multiply by our forecast book value per share for 2011E to derive targets (**Exhibit 40**).

Exhibit 39
ROE% drives P/B multiples



Source: Bernstein estimates

Exhibit 40
Summary of Valuation for Integrated majors

Summary of Price Targets		
	PTR	SNP
Cur.	HKD	HKD
2011E ROE	20.5%	14.3%
Target P/BV*	2.0	1.3
2011E BVPS	6.2	6.1
Price Target	12.5	7.9

For SNP we apply a 20% discount to P/BV due to regulated refining margins

Source: Bernstein estimates

Risks

PetroChina: downside risks to our PetroChina price target include a decline in oil prices given the high correlation and beta with oil, accelerated production decline at Daqing oil field and larger than expected losses in their refining division as a result of government fuel price subsidies. Better than expected refining margins and domestic gas prices as a result of policy changes represent an upside risk to our price target.

Sinopec: Risks to our Sinopec price target include a decline in oil prices given the high correlation and beta with oil, accelerated production decline at Shengli oil field and overseas M&A transaction with their parent company which results in value leakage from the company. Better than expected refining margins as a result of policy changes represent an upside risk to our price target.

SRO REQUIRED DISCLOSURES

- References to "Bernstein" relate to Sanford C. Bernstein & Co., LLC, Sanford C. Bernstein Limited, and Sanford C. Bernstein, a unit of AllianceBernstein Hong Kong Limited, collectively.
- Bernstein analysts are compensated based on aggregate contributions to the research franchise as measured by account penetration, productivity and proactivity of investment ideas. No analysts are compensated based on performance in, or contributions to, generating investment banking revenues.
- Bernstein rates stocks based on forecasts of relative performance for the next 6-12 months versus the S&P 500 for stocks listed on the U.S. and Canadian exchanges, versus the MSCI Pan Europe Index for stocks listed on the European exchanges (except for Russian companies), versus the MSCI Emerging Markets Index for Russian companies and stocks listed on emerging markets exchanges outside of the Asia Pacific region, and versus the MSCI Asia Pacific ex-Japan Index for stocks listed on the Asian (ex-Japan) exchanges - unless otherwise specified. We have three categories of ratings:

Outperform: Stock will outpace the market index by more than 15 pp in the year ahead.

Market-Perform: Stock will perform in line with the market index to within +/-15 pp in the year ahead.

Underperform: Stock will trail the performance of the market index by more than 15 pp in the year ahead.

Not Rated: The stock Rating, Target Price and estimates (if any) have been suspended temporarily.

- As of 05/07/2010, Bernstein's ratings were distributed as follows: Outperform - 46.6% (1.0% banking clients) ; Market-Perform - 46.9% (1.0% banking clients); Underperform - 6.5% (0.0% banking clients); Not Rated - 0.0% (0.0% banking clients). The numbers in parentheses represent the percentage of companies in each category to whom Bernstein provided investment banking services within the last twelve (12) months.
- Neil Beveridge maintains a long position in BP PLC (BP).
- In the next three (3) months, Bernstein or an affiliate expects to receive or intends to seek compensation for investment banking services from 386.HK / China Petroleum & Chemical Corp, SNP / China Petroleum & Chemical Corp, 857.HK / PetroChina Co Ltd, PTR / PetroChina Co Ltd.

12-Month Rating History as of 05/16/2010

Ticker Rating Changes

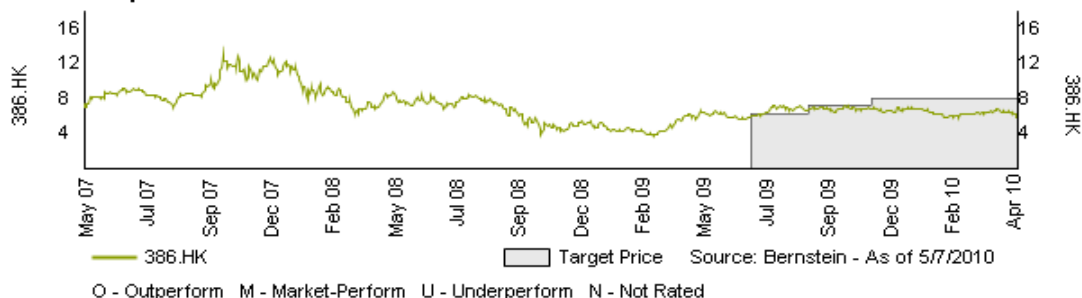
386.HK M (IC) 06/29/09
 857.HK O (IC) 06/29/09
 PTR O (IC) 06/29/09
 SNP M (IC) 06/29/09

Rating Guide: O - Outperform, M - Market-Perform, U - Underperform, N - Not Rated
 Rating Actions: IC - Initiated Coverage, DC - Dropped Coverage, RC - Rating Change

386.HK / China Petroleum & Chemical Corp

Date	Rating	Target(HKD)
06/29/09	M(IC)	6.10
09/04/09	M	7.10
11/17/09	M	7.90

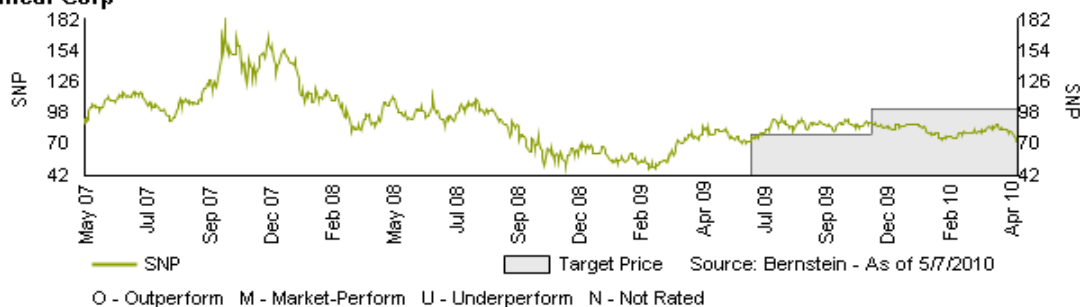
IC - Initiated Coverage



SNP / China Petroleum & Chemical Corp

Date	Rating	Target(USD)
06/29/09	M(IC)	79.00
11/17/09	M	102.00

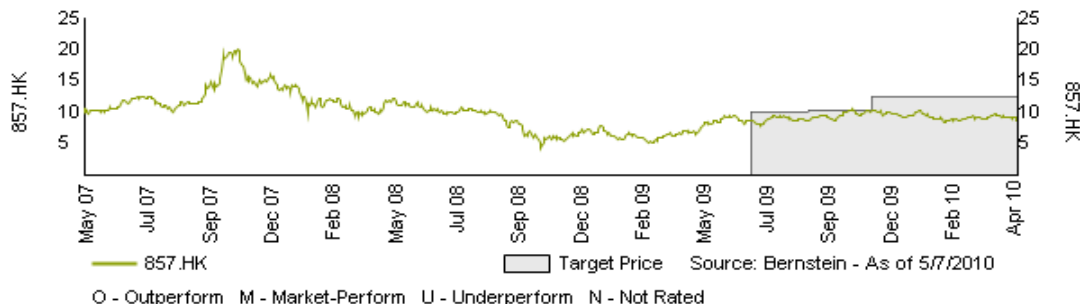
IC - Initiated Coverage



857.HK / PetroChina Co Ltd

Date	Rating	Target(HKD)
06/29/09	O(IC)	9.80
09/04/09	O	10.10
11/17/09	O	12.50

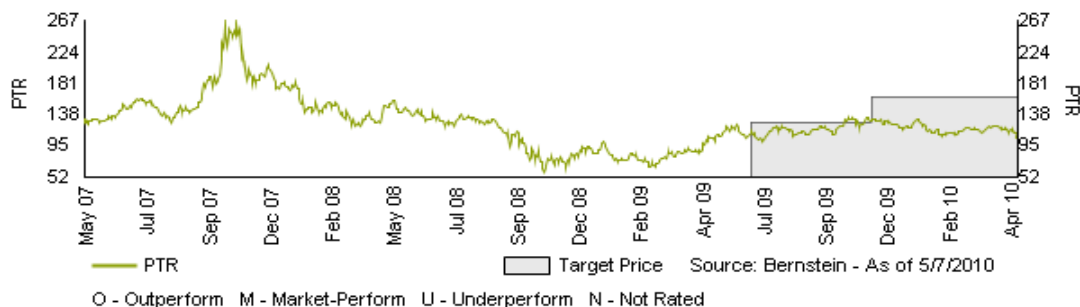
IC - Initiated Coverage



PTR / PetroChina Co Ltd

Date	Rating	Target(USD)
06/29/09	O(IC)	126.00
11/17/09	O	161.00

IC - Initiated Coverage



OTHER DISCLOSURES

A price movement of a security which may be temporary will not necessarily trigger a recommendation change. Bernstein will advise as and when coverage of securities commences and ceases. Bernstein has no policy or standard as to the frequency of any updates or changes to its coverage policies. Although the definition and application of these methods are based on generally accepted industry practices and models, please note that there is a range of reasonable variations within these models. The application of models typically depends on forecasts of a range of economic variables, which may include, but not limited to, interest rates, exchange rates, earnings, cash flows and risk factors that are subject to uncertainty and also may change over time. Any valuation is dependent upon the subjective opinion of the analysts carrying out this valuation.

This document may not be passed on to any person in the United Kingdom (i) who is a retail client (ii) unless that person or entity qualifies as an authorised person or exempt person within the meaning of section 19 of the UK Financial Services and Markets Act 2000 (the "Act"), or qualifies as a person to whom the financial promotion restriction imposed by the Act does not apply by virtue of the Financial Services and Markets Act 2000 (Financial Promotion) Order 2005, or is a person classified as an "professional client" for the purposes of the Conduct of Business Rules of the Financial Services Authority.

To our readers in the United States: Sanford C. Bernstein & Co., LLC is distributing this publication in the United States and accepts responsibility for its contents. Any U.S. person receiving this publication and wishing to effect securities transactions in any security discussed herein should do so only through Sanford C. Bernstein & Co., LLC.

To our readers in the United Kingdom: This publication has been issued or approved for issue in the United Kingdom by Sanford C. Bernstein Limited, authorised and regulated by the Financial Services Authority and located at Devonshire House, 1 Mayfair Place, London W1J 8SB, +44 (0)20-7170-5000.

To our readers in member states of the EEA: This publication is being distributed in the EEA by Sanford C. Bernstein Limited, which is authorised and regulated in the United Kingdom by the Financial Services Authority and holds a passport under the Investment Services Directive.

To our readers in Hong Kong: This publication is being issued in Hong Kong by Sanford C. Bernstein, a unit of AllianceBernstein Hong Kong Limited. AllianceBernstein Hong Kong Limited is regulated by the Hong Kong Securities and Futures Commission.

To our readers in Australia: Sanford C. Bernstein & Co., LLC and Sanford C. Bernstein Limited are exempt from the requirement to hold an Australian financial services licence under the Corporations Act 2001 in respect of the provision of the following financial services to wholesale clients:

- providing financial product advice;
- dealing in a financial product;
- making a market for a financial product; and
- providing a custodial or depository service.

Sanford C. Bernstein & Co., LLC, Sanford C. Bernstein Limited and AllianceBernstein Hong Kong Limited are regulated by, respectively, the Securities and Exchange Commission under U.S. laws, by the Financial Services Authority under U.K. laws, and by the Hong Kong Securities and Futures Commission under Hong Kong laws, all of which differ from Australian laws.

One or more of the officers, directors, or employees of Sanford C. Bernstein & Co., LLC, Sanford C. Bernstein Limited, Sanford C. Bernstein, a unit of AllianceBernstein Hong Kong Limited, and/or their affiliates may at any time hold, increase or decrease positions in securities of any company mentioned herein.

Bernstein or its affiliates may provide investment management or other services to the pension or profit sharing plans, or employees of any company mentioned herein, and may give advice to others as to investments in such companies. These entities may effect transactions that are similar to or different from those recommended herein.

Bernstein Research Publications are disseminated to our customers through posting on the firm's password protected website, www.bernsteinresearch.com. Additionally, Bernstein Research Publications are available through email, postal mail and commercial research portals. If you wish to alter your current distribution method, please contact your salesperson for details.

Bernstein and/or its affiliates do and seek to do business with companies covered in its research publications. As a result, investors should be aware that Bernstein and/or its affiliates may have a conflict of interest that could affect the objectivity of this publication. Investors should consider this publication as only a single factor in making their investment decisions.

This publication has been published and distributed in accordance with Bernstein's policy for management of conflicts of interest in investment research, a copy of which is available from Sanford C. Bernstein & Co., LLC, Director of Compliance, 1345 Avenue of the Americas, New York, N.Y. 10105, Sanford C. Bernstein Limited, Director of Compliance, Devonshire House, One Mayfair Place, London W1J 8SB, United Kingdom, or Sanford C. Bernstein, a unit of AllianceBernstein Hong Kong Limited, Director of Compliance, Suite 3401, 34th Floor, One IFC, One Harbour View Street, Central, Hong Kong.

CERTIFICATIONS

- I/(we), Neil Beveridge, Ph.D., Senior Analyst(s), certify that all of the views expressed in this publication accurately reflect my/(our) personal views about any and all of the subject securities or issuers and that no part of my/(our) compensation was, is, or will be, directly or indirectly, related to the specific recommendations or views in this publication.

Approved By: NK

Copyright 2010, Sanford C. Bernstein & Co., LLC, Sanford C. Bernstein Limited, and AllianceBernstein Hong Kong Limited, subsidiaries of AllianceBernstein L.P. ~ 1345 Avenue of the Americas ~ NY, NY 10105 ~ 212/756-4400. All rights reserved.

This publication is not directed to, or intended for distribution to or use by, any person or entity who is a citizen or resident of, or located in any locality, state, country or other jurisdiction where such distribution, publication, availability or use would be contrary to law or regulation or which would subject Bernstein or any of their subsidiaries or affiliates to any registration or licensing requirement within such jurisdiction. This publication is based upon public sources we believe to be reliable, but no representation is made by us that the publication is accurate or complete. We do not undertake to advise you of any change in the reported information or in the opinions herein. This publication was prepared and issued by Bernstein for distribution to eligible counterparties or professional clients. This publication is not an offer to buy or sell any security, and it does not constitute investment, legal or tax advice. The investments referred to herein may not be suitable for you. Investors must make their own investment decisions in consultation with their professional advisors in light of their specific circumstances. The value of investments may fluctuate, and investments that are denominated in foreign currencies may fluctuate in value as a result of exposure to exchange rate movements. Information about past performance of an investment is not necessarily a guide to, indicator of, or assurance of, future performance.