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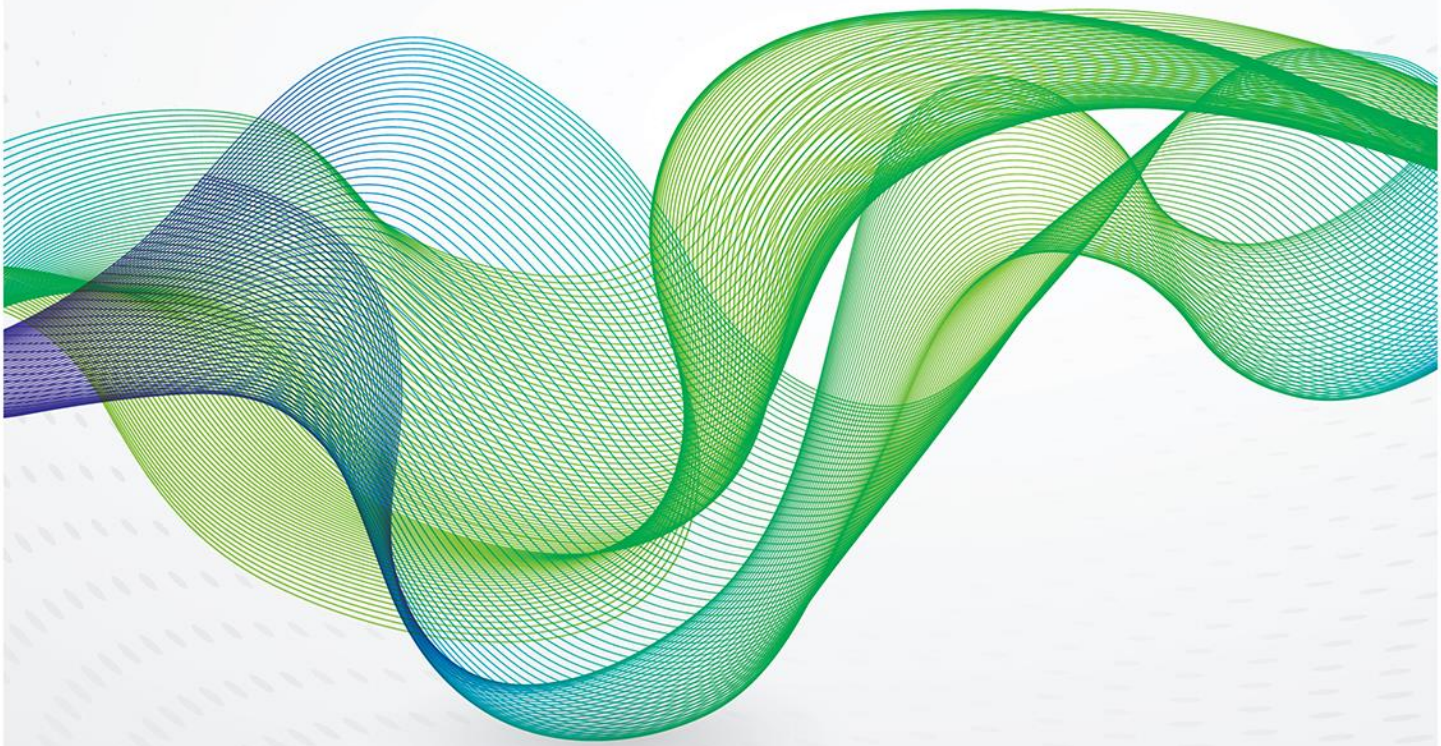
China's Long March to Gas Price Freedom: Price Reform in the People's Republic



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Preface

The outlook for the Chinese gas market is one of the biggest questions in the global gas market today but understanding the detailed matrix of interlinking economic and political catalysts which will determine the future of demand and sources of supply is a complex job. In this extensive report Stephen O'Sullivan provides a detailed review of the key issues involved, in particular through the lens of gas pricing. This viewpoint provides an interesting way to analyse the dichotomies in the Chinese gas sector, as the government tries to incentivise demand growth and coal to gas switching with a low price while also attempting to increase domestic production with a high price. In addition, the question of state companies losing money on imports when highly priced LNG must be sold into a market with lower regulated prices remains a contentious issue. This report analyses how the Beijing authorities have attempted to manage this dilemma using regulated prices while also attempting to provide a link to international markets, but also identifies a number of other themes that will be crucial to the future of gas demand growth in the country. While we would hesitate to claim that this research provides answers to the multitude of questions involved, it does offer an important foundation for understanding the manifold complexities of the Chinese gas sector.

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Contents

Figures

Tables

Glossary

bcm – billion cubic metres

CBM – Coal bed Methane

CNOOC – China National Offshore Oil Corporation

CNPC – China National Petroleum Corporation (parent of PetroChina)

EIA – US Energy Information Administration

IEA – International Energy Agency

LNG – Liquefied Natural Gas

MLR – Ministry of Land and Resources

mmBtu – million British thermal units

NBS – National Bureau of Statistics

NDRC – National Development and Reform Commission

NEA – National Energy Administration

NGD – Natural Gas Daily

NOCs – National Oil Companies

Sinopec – China Petroleum and Chemical Corporation

WGI – World Gas Intelligence

Introduction

China is the world's largest energy economy, having overtaken the US in 2009.[1] Gas remains a relatively small part of the country's energy supplies at less than 7% in 2017. However, with a focus on cleaning up China's heavily polluted environment, the government's target is for gas to represent as much as 10% of total energy supply in 2020 and 15% by 2030.[2]

A very large gas market

As a result of sustained economic growth and supportive government policies, China has now become the third-largest market for gas in the world[3] and demand continues to increase at high double-digit rates. While China is the sixth-largest gas producer in the world, domestic production has not kept pace with demand. Increasingly the shortfall has been made up with imports and China is now the third-largest overall gas importer overall and the second-largest importer of LNG.[4]

Increasingly dependent on imports

As a result, since gas imports began twelve years ago, the country has become increasingly integrated with the world energy economy as both LNG and pipeline gas volumes have been acquired under long-term and spot contracts to feed China's growing energy needs. Gas import dependency has risen to above 40% from effectively zero in just twelve years. While the government supports the increased use of gas in the economy, this has come at a cost in terms of the increased import dependency and a pricing system that fails to reflect the true cost of gas to China, whether domestically produced or imported.

Pricing has an impact on all aspects of the gas sector:

- Encouraging the development of domestic gas production
- Stimulating unconventional domestic gas production
- Remunerating costly imports of LNG and pipeline gas
- Eliminating cross-subsidies between sectors
- Encouraging consumption but in an economically rational manner
- Reducing pollution caused by coal and other high-carbon fuel sources.

Government policy currently the key driver of gas demand growth

The development of China's gas sector and the country's demand for gas has, to a large degree, been driven by government policy in the past – a factor that remains a dominant driver today. Most recently this has manifested itself through Beijing's policy on coal-to-gas switching in the industrial sector. However, as the sector steadily moves towards a more market-oriented – and sustainable – footing, perhaps the government's key challenge for the future is to find a price – and a process for arriving at that price – which both encourages demand for gas, to support the policy objective of increasing its use to curb pollution, while at the same time stimulating production from conventional and unconventional sources, thereby reducing or slowing China's growing dependence on imports to meet the rising gas demand.

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[1] BP Statistical Review of World Energy 2018
[2] China's 13th Five-Year Plan, cited by Energy Information Administration 25 October 2017
[3] BP Statistical Review of World Energy 2018
[4] BP Statistical Review of World Energy 2018

Gas pricing gradually being liberalized

In order to move the sector towards a sustainable future, the government has been liberalizing gas pricing over what is now a long period. However the process has been both unpredictable and spasmodic. In recent years, however, the pace has picked up, with the most recent development being the effective liberalization of the politically sensitive residential pricing framework by June 2019.

Chapter 1 of this paper outlines the overall Chinese gas sector reform process and where pricing reform fits within it. Chapter 2 identifies the case for price reform. Chapter 3 describes and analyses China's long path to market pricing. Chapter 4 analyses the impact of pricing on gas demand, both recently and in the medium-term. Chapter 5 looks at the regional variations in gas demand and pricing. Chapter 6 sets out the key achievements of China's gas pricing reforms and identifies the main issues which remain outstanding before the reform process can be considered complete. Chapter 7 draws some overall conclusions from our research.

1. Overall Chinese gas sector reform process

In this section we discuss the broad context of Chinese gas sector reform and where pricing reform fits within it. We identify the government's main objectives for sector and price reform, the rationale behind the reform process and assess whether they are likely to be achieved – particularly in the light of the impact of government policies over the 2017/18 winter season.

1.1 Five-Year Energy Plan

China's gas sector reform objectives can be seen in outline in the current 13th Five-Year Energy Plan, released in 2017.[5] Most of the targets were not really new, they aligned fairly closely with previously-announced targets, such as those announced in 2014's Strategic Energy Action Plan, the China Natural Gas Development Report of 2016,[6] the 12th Five-Year Plan and the Opinions released in early 2017.[7]

The main components are:

- Promotion of gas and renewables at the expense of coal
- Total energy consumption capped at less than 5 Gtce
- Coal to represent less than 58% of primary energy consumption
- Installed gas-fired power generating capacity to reach 110GW by 2020, 5% of total capacity
- Gas sector reform – in particular price reform – is also a key focus.

There are of course many challenges. These include the growing overcapacity in the coal-fired power sector as slowing economic growth has left many plants underutilized. There are also curtailment issues with renewables as insufficient grid capacity exists to transmit the power from where it is generated to the large demand centres in the east and south of the country.

Initiatives focused on boosting gas use

There are a number of specific initiatives designed to increase the role of gas in China's energy economy, which we discuss below:

- Increasing gas use to reduce pollution through pricing reform, infrastructure investment and active policies
- Improved infrastructure access which should lower prices to end-users
- Upstream and downstream reform
- Development of gas hubs.

We also highlight the medium-term challenge from renewables.

1.2 Increasing gas use to reduce pollution

Among the key energy policy objectives in China is increasing the proportion of natural gas in the country's energy mix. The main driver behind this objective is the need to reduce pollution in China and improve the urban environment. Coal is a major contributor to China's environmental problems and reducing the use of coal in favour of natural gas – as well as other energy types such as nuclear and renewables – is one of the major ways of reducing carbon emissions and curbing pollution.

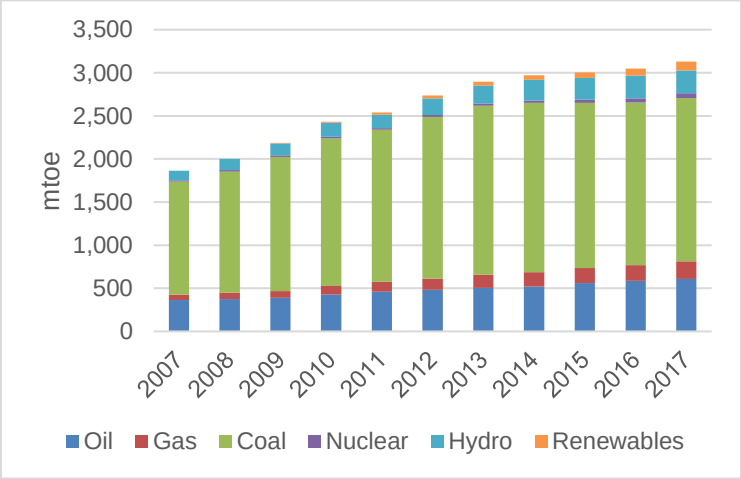
[5] National Energy Administration January 2017
[6] National Energy Administration, cited in Development Research Centre of the State Council 16 May 2017
[7] Opinions on China Oil and Gas System Reform, cited in Xinhua 22 May 2017 http://news.xinhuanet.com/english/2017-05/22c_136302954.htm

Hence reducing pollution through the greater use of gas is going to remain a key energy reform objective in China for the foreseeable future, as we see with the government's current push to replace coal with gas.

Overall Chinese energy consumption rose by 3.4% in 1H18, a period when GDP rose by 6.8%.[8] Coal's share of total consumption declined by 1.3% in 1H18 although total coal consumption actually rose because of the increase in total energy demand.

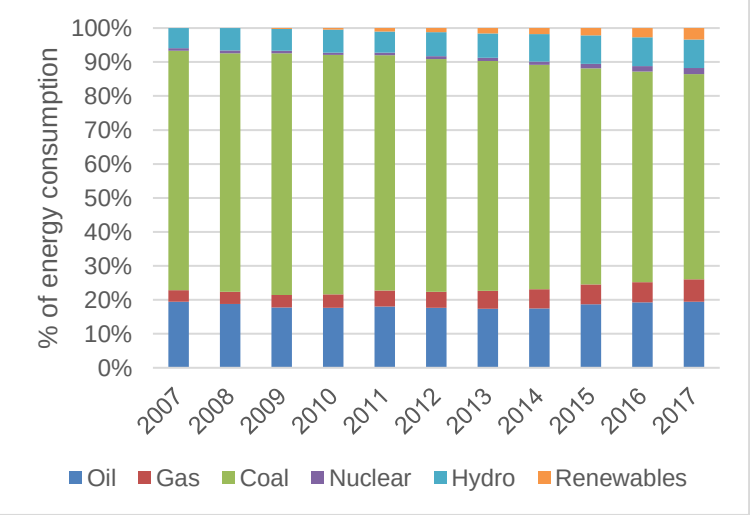
The share of natural gas in China's energy mix has been steadily rising, as seen in Figures 1 and 2 below. In 2010 it was4 % while the most recent data (for 2017) place it at 6.6%[9] and the government's target for 2018 is 7.5%. Renewables, hydro and nuclear have also all increased their share of energy consumption since 2010 – while coal's share has declined from over 70% to 62% in 2017.[10]

Figure 1: China energy consumption by fuel, 2007–2017



Source: BP Statistical Review of World Energy 2018

Figure 2: Share of fuels in energy consumption, 2007–2017



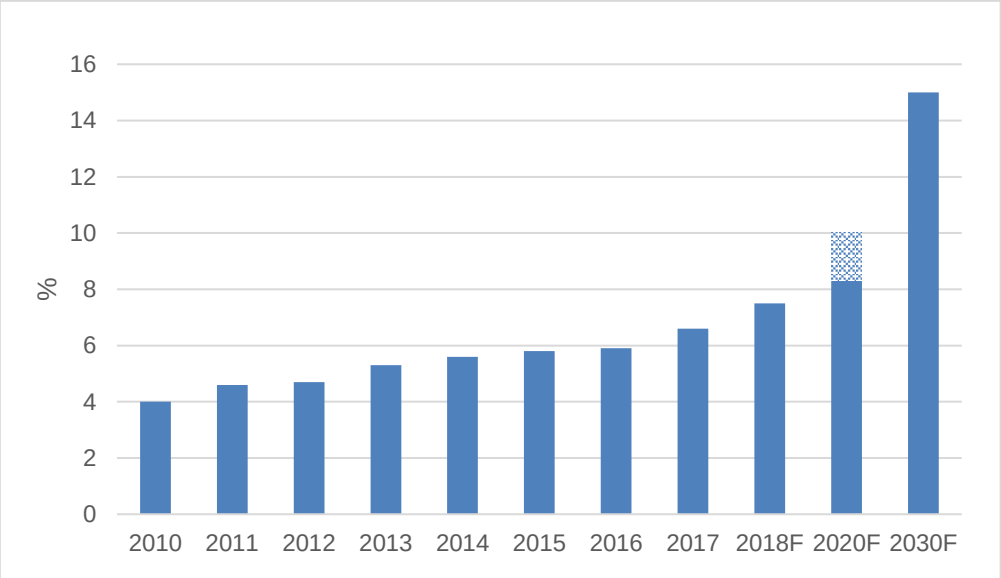
Source: BP Statistical Review of World Energy 2018

[8] National Bureau of Statistics, cited in World Gas Intelligence 1 August 2018
[9] BP Statistical Review of World Energy 2018
[10] BP Statistical Review of World Energy 2018

Ambitious targets for gas use

The official government target for 2020 is now for gas to represent 8.3-10% of total Chinese energy use; the earlier point target of 10% was downgraded to this new range in January 2017 reflecting the then-reality of slower than anticipated growth in gas demand. In order for the 10% target to be achieved, many observers believe there is a need for a continuing strong focus by the government on coal-to-gas switching, third-party access to gas infrastructure and reducing the final gas price to the consumer - as well as actually enforcing the policies that the government develops. National Energy Administration officials have suggested that China's gas consumption would need to reach 350-360 bcm/year by 2020 if the 10% target were to be met. With 2017 consumption at 237 bcm/year, that would require annual increases of 14-15% in gas demand. This level of demand increase is plausible, given the government's gas promotion policies and their continuing strong impact on recent gas demand (up 17.5% in 1H18). However, securing up to 120 bcm/year of additional gas may prove difficult and would likely be expensive since the marginal volumes would almost certainly have to come in the form of LNG.

Figure 3: Gas as proportion of total China energy consumption, 2010–2030F



Source: National Bureau of Statistics, BP Statistical Review of World Energy 2018, TS Lombard

By 2030 the government plans for gas to represent 15% of total primary energy consumption[11] (approximately 600 bcm/year according to the State Council) as it further reduces the proportion of coal used in China's energy economy – less so through coal to gas switching in the industrial sector and more so through a potential increase in gas-fired power generation. CNPC has said that it expects further increases in the use of gas as a proportion of total Chinese energy supply because the average share of gas in developed markets is typically more than 20%.[12]

Political will to achieve environmental improvements

Of course these targets will not achieve themselves. Stronger government policies in support of gas are likely to continue to be needed to achieve them. Nur Bekri, the recently-dismissed head of the National Energy Administration (NEA) noted last year that the NEA would aim to publish a list of

[11] Natural Gas Daily 28 April 2017
[12] Lin Boqiang, China Centre for Energy Economics Research, cited in Natural Gas Daily 1 November 2017

sectors which would be instructed to increase gas use, including power generation and transport. He also indicated that the NEA would press for further price reforms, including a mechanism to link electricity prices to gas prices to encourage power generators to increase their use of gas, and for greater third-party access to gas pipelines, import terminals and storage facilities.

China's annual parliamentary meetings in 1Q17 saw Premier Li Keqiang propose a series of policies aimed at increasing gas use and improving the environment.[13] These included:

- The closure of at least 150 mn tonnes of coal production capacity
- Removing 50GW of coal-fired generating capacity from the system to free up space for clean energy
- Reducing small-scale domestic coal burn
- Replacing coal with electricity and gas in 3 million households.

Premier Li indicated that later in 2017 more detailed policies implementing these proposals would be issued and in May that year China released its summary of proposed reforms. Titled 'Opinions on China Oil and Gas System Reform'[14] it set out proposals for upstream, midstream and downstream reform, including access to infrastructure and the changes to the pricing system for natural gas in China.

At the very end of 2017, the NDRC, the NEA and various other government bodies announced that the government wanted to double the amount of gas burned for winter heating in northern China - with the majority of growth coming from cities. Increased residential demand, power generation, and district heating will be the big areas of growth – although pricing and infrastructure availability will be important influences on whether these objectives become reality.

Implementation of policies is critical

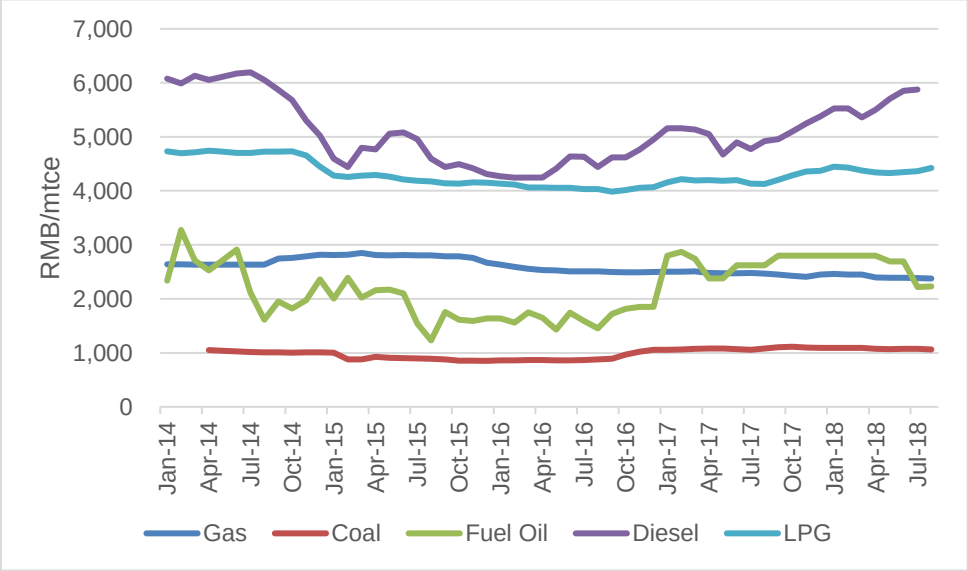
While these are positive statements of intent, the key will be in their implementation. Some observers are optimistic that the government will take this opportunity to make good on its promises of reform and have suggested that the priorities should be price liberalization and third-party access to infrastructure. Clearly these factors are important elements of reform. However it seems clear that gas pricing relative to that of coal and oil is also an important factor in determining the rate at which gas demand grows; the very important power generation market has so far been relatively resistant to sharply increased levels of gas utilization because of the challenging economics.

It may be that government policy – which we have seen play the most important role in driving gas demand in recent years – will also come to play a key role in the power generating sector. Premier Li's 2017 statement to China's parliament and the subsequent Opinions certainly seem to point in that direction with their talk of retiring coal-fired generating capacity and replacing coal with electricity and gas in the household sector.

Looking at Figure 4 below, which is based on data sourced from the NDRC for each major fuel type supplied to China's industrial sector, converted into RMB/mtce for consistency, we can conclude that policy direction may be required. Natural gas is not price-competitive with coal in the China market and the government's focus has indeed been on encouraging its use as part of China's environmental remediation programme. Coal itself is the cheapest source of energy in China and has been for many years. Even today it is roughly 55% cheaper than natural gas in the industrial market – a lower discount than in the past but still a sizeable disincentive to switch to gas. In the last few months fuel oil has been more expensive than gas after being cheaper for the three years before that, while diesel and LPG have been, and remain, considerably more expensive than gas in the industrial sector.

[13] Natural Gas Daily 21 March 2017
[14] As reported in Xinhua 22 May 2017

Figure 4: Energy cost comparison – China industrial sector average, 2014–2018



Source: NDRC, CEIC, Lawrence Livermore National Laboratory

Shortly after the 2017 parliamentary sessions, China released an air action plan to reduce air pollution.[15] The plan was applicable to 28 cities around the heavily-polluted Beijing-Tianjin-Hebei region and involved restrictions on production activity in industries such as coal, steel and cement, all of which were heavy polluters. All cement and casting plants in the 28 cities – as well as in four neighbouring provinces – were forced to shut down between mid-November 2017 and mid-March 2018 unless they were providing essential heating services. In addition, any coal-fired generating plant which was unable to meet the country's low emission standards by the end of October 2017 was forced to close for the winter period.

Subsidies considered but may not have a huge impact

China's finance ministry also indicated that it would trial subsidies in some of the 28 polluted cities as a way of encouraging the use of gas-fired heating in the winter. Subsidies of RMB0.5-1 billion ($73-146 mn) were to be made available to the chosen cities and reports suggest that twelve pilot cities were selected. However critics of this policy – often within the gas industry - highlight that subsidies are unlikely to be a long-term answer and cite the example of Beijing. The Beijing city government offers subsidies to encourage the use of gas but, despite an improvement in the environment, pollution still remains a concern in Beijing. It appears as if the limit of Beijing's ability to pay has been reached, which suggests that if Beijing's subsidies – from China's richest city – are unable to conclusively change behaviour, smaller, and less prosperous, cities are unlikely to be able to achieve such a change either.

Apart from government policy (and economic growth) lower natural gas prices – in both absolute and relative terms - appear to be the most effective way of stimulating both relative and absolute growth in gas demand as a way of improving China's environment. Hence the longstanding focus on price and sector reform to achieve this.

The winter gas shortages

Both infrastructure and pricing constraints have created serious gas shortages in China over the last year.

[15] China Daily, cited in Natural Gas Daily 30 March 2017

With the structural focus on encouraging coal-to-gas switching, gas shortages began to become evident even before the onset of the winter 2017/18 heating season in northern China and subsequently spread to eastern and central China. In some of the 28 northern cities in which Beijing had ordered coal users to switch to gas for heating over the winter, the authorities were forced to suspend gas supplies to residential users as well as to commercial and industrial users – reopening some coal-fired power plants and allowing some residential coal burning - an almost unheard of action given the government's desire for social stability. Gas traders predicted that by the time the heating season ended in March, gas supplies to industry across much of China would have been suspended, forcing businesses to close. CNPC estimated that it would need to cut supplies to industrial users by between 3-10% because the coal-to-gas switching programme alone is estimated to have added 12% to China's gas consumption with Beijing, Tianjin and Hebei province accounting for 40% of this increase in demand.

Overall, some 3.94 million households in northern China were switched from coal to gas in 2017, almost a million more than initially planned – which explains the unexpected gas shortages that occurred during the winter of 2017/18. A further 4 million households are planned to be converted in 2018[16], with the government promising to ensure availability of sufficient gas to meet the new demand. A subsequent statement from the government indicated that 3.92 mn households would be switched from coal to gas for heating in the same region by October[17], which suggests that despite the slight loosening of some of the initial 2018 pollution targets (discussed on page 15), perhaps because of the escalating strains in the US trade relationship, the coal-to-gas switching policy and programme remains broadly intact.

One of the main causes of the shortages was the absence of sufficient gas supplies to meet the new demand created by the coal to gas switching programme in northern China. In their desire to meet central government targets for environmental improvement, local governments removed coal boilers and home heating furnaces but failed to secure sufficient additional gas supplies and to construct local gas pipelines and other infrastructure to replace the lost coal supplies.

Other serious infrastructure issues included insufficient pipeline capacity, limited pipeline access, inadequate storage and LNG terminal availability - all of which contributed to the problems that northern China experienced towards the end of 2017. The resulting – and widely-publicized - gas shortages will also affect the implementation of China's future infrastructure plans, as energy users converting to gas will no doubt question whether they will actually receive the gas they have been promised. The government's response was to cut supplies of gas to industrial users (some of which had only just switched from coal to gas) in order to protect household supplies, while the oil companies themselves reduced supplies to domestic LNG plants, prompting sharp price moves.

The fundamental issue for Chinese gas is that the government's laudable efforts to increase the use of gas in the country to improve its environment (estimated by CNPC to add 85 bcm/year – about a third of current levels - to Chinese demand by 2020) are moving at a faster pace than developments in infrastructure. The speed of transition from burning coal to burning gas is much faster than pipelines, import capacity and storage tanks can be constructed.

Pipeline ownership remains an unresolved question

The majority of China's gas infrastructure is owned by the three major oil companies (PetroChina/CNPC, Petrochina, Sinopec and CNOOC) which have been moving slowly in expanding it. In the case of pipeline construction this has been because of long-standing government plans to create a national pipeline company to take over the country's long-distance pipelines; in addition, some of the local distribution pipelines to take gas from the high-pressure pipelines into many cities have yet to be completed. Hence many consumers encouraged (or forced) by the government to

[16] Ministry of Environmental Protection, cited in Natural Gas Daily 9 February 2018
[17] Ministry of Ecology and Environment, cited in Natural Gas Daily 3 August 2018

switch from coal to gas were left without supply last winter. Improving infrastructure connections took centre-stage in July this year when the State Council published a three-year action plan to reduce air pollution.[18]

The plan envisages reduced coal consumption, more electric vehicles and the closure of more steel and coke capacity over the next three years. It covers 82 cities across China, an increase from the 28 cities covered in the 2013-2017 plan. With gas supplies unevenly distributed between north and south China - particularly at times of peak demand – the central government has also been pushing the oil companies to establish more interconnections between their networks and storage facilities and all three major companies are working on projects to link their infrastructure. CNPC, for example, plans to spend RMB25.8 bn ($3.7 bn) on improving interconnectivity and highlighted recently that projects completed so far could carry up to 10.8 bcm/year of gas from southern China to northern China if necessary.[19]

Gas storage issues

In the case of storage the companies are reluctant to invest in additional capacity because of the poor returns from this segment of their operations in the absence of predictable seasonal price changes which would justify the investment. China's gas storage capacity is just 10 bcm,[20] 4% of its domestic consumption.[21] The government is targeting storage of 5% of consumption by 2020 and nearly 6% by 2030,[22] considerably lower than the almost 12% of demand seen in many mature gas markets[23] and the 25% seen in a highly developed gas market such as Germany[24] with the companies blaming the lack of government incentives - such as a greater degree of formally established seasonal pricing - for the country's limited storage capacity (although there are also geological limitations on it). PetroChina is developing a medium-to long term gas storage development plan, involving more underground storage and the expansion of two LNG receiving terminals.[25] CNPC will bring additional storage on stream by 2025 as part of the Russian pipeline project, which will take its total capacity to 15 bcm.[26] The company has also announced plans to add an additional 21 bcm of storage capacity although has not given any indication of the timescale associated with this.[27]

China's current Five-Year Plan set a target for working storage capacity to reach 14.8 bcm by 2020 (almost half as much again as the current level) and as much as 30 bcm in 2030. The NDRC and the NEA suggested last April that gas suppliers should increase storage capacity. The NEA issued a notice to speed up the construction of more gas storage – including the creation of independent gas storage operators and set specific targets for gas suppliers to construct storage equivalent to 10% of annual supply, while city gas distributors should hold 5% of supply in their storage capacity.[28] However this suggestion is unlikely to have much impact because it has no legal force and there is a long-standing reluctance to charge households a peak shaving price to recover the cost of storage –

[18] State Council http://www.gov.cn/zhengce/content/2018-07/03/content_5303158.htm, cited in Natural Gas Daily 4 July 2018
[19] CNPC, cited in Natural Gas Daily 16 August 2018
[20] National Energy Administration, cited in International Energy Agency Gas Market Report 2018. A figure of 11.7 bcm is also quoted by other sources while World Gas Intelligence quotes a figure of 3.3% of demand, equivalent to 8 bcm
[21] Duan Zhaofang: China Natural Gas Market Share and Outlook 8 November 2017, cited in International Energy Agency Gas Market Report 2018
[22] World Gas Intelligence 9 May 2018
[23] Natural Gas Daily 12 March 2018
[24] International Energy Agency Gas Market Report 2018
[25] China Securities Journal, cited in Natural Gas Daily 6 July 2018
[26] Natural Gas Daily 15 March 2018
[27] Xinhua, cited in Natural Gas Daily 19 March 2018
[28] National Energy Administration, cited in International Energy Agency Gas Market Report 2018 and World Gas Intelligence 9 May 2018

even though this has been allowed by the NDRC.[29] The government also recently agreed to provide subsidies until 2020 to encourage companies to build new above-ground storage.

CNPC may be an exception in terms of constructing new storage capacity in that it does have the funds and may want to maintain its good relationship with the government, something that less well-off local governments and private sector suppliers may not have the funds to do. The gas companies argue that seasonal pricing – higher winter prices - would make it more attractive to build storage to enable them to purchase gas at summer prices and sell it at higher winter prices. However, as we note later, in both the 2016/17 and 2017/18 winters seasonal pricing has been in place. PetroChina and Sinopec did actually raise prices during the winter heating season and that seems to be happening again in the 2018/19 winter.

Rising domestic prices

Increased prices were also a driver of the crisis. Domestic LNG prices (for LNG manufactured from pipeline gas and often delivered to customers by road) have been deregulated and they doubled within a month, making them unaffordable for many businesses. LNG producers were also unable to acquire sufficient feedstock from the NOCs as we note above, and what they could source came at a higher price. Supplies of gas to LNG plants were cut back to maintain residential supplies and prices rose to levels more than 50% above government-set prices for feedstock (with end-user prices reaching $29/mmBtu at the end of 2017). The government requested LNG producers to stop increasing prices because it was destroying gas demand, although given that regulation had been eased, there was no guarantee that this would necessarily happen. In reality, prices did fall because consumers – faced with much higher domestic prices – were simply unable to afford the gas and, as a result, consumption fell sharply.

Government response to shortages

Faced with widespread gas shortages, the government was left with few options to provide immediate relief. A combination of increased industrial sector demand resulting from the coal to gas switching programme and rising residential demand as cold weather descended on China meant that shortages were reported across the country as far south as Jiangsu. Connections to the gas grid had run well ahead of the capacity of the gas grid to meet the increased demand.

The solution chosen was to reduce supplies to industry and power plants to protect residential users;[30] to scale back the ambitious plans to convert coal-burning users in northern cities to gas with the government allowing Beijing, Tianjin and several northern provinces to suspend the conversion process and ensure that those already converted were receiving adequate gas supplies as well as to charter LNG tankers as storage vessels anchored off the country's LNG receiving terminals. Longer-term, as we identify later, more gas storage capacity is going to be essential for China to enable it to cope with the peaks of winter demand, even while seasonal pricing has been implemented by the gas companies during the winters of 2016/17 and 2017/18. One possibility is to construct additional LNG storage capacity at LNG import terminals – in the same way as South Korea has (China has more LNG import terminals than South Korea but the latter has far more storage). The challenge here is that Chinese LNG import terminals are often built on reclaimed land which could make building storage there more problematic.[31]

Modest easing of environmental targets in recent years

Until political tensions with the US increased during 2018, it seemed unlikely that the government would ease up on its policies aimed at improving the environment through coal-to-gas switching. Despite the gas shortages, the impact of smog on, for example, Beijing had been reduced – although

[29] NDRC, cited in Natural Gas Daily 31 August 2018 http://www.sdpc.gov.cn/zwfwzx/zfdj/jggg/201610/t20161019_823111.html
[30] Natural Gas Daily 2 January 2018
[31] Discussion with energy analysts in China March 2018; State Oceanic Administration, cited in World Gas Intelligence 14 February 2018

not eliminated - during the winter of 2017/18, while smog levels in eastern China – which was not subject to the same rules on the use of coal – rose. However the Chinese government now looks set to take a softer line on pollution mitigation as the 2018/19 winter approaches. Targets for PM2.5[32] reduction and the number of days with severe air pollution have both been loosened from a 5% reduction against 2017 levels to just 3% – both of which are much lower than the 2017/18 targets of at least 15%. It does seem as if economic growth, in the face of a growing trade war, is being prioritized over pollution control.

Hence, while there will continue to be government support for coal-to-gas switching, some of the extremes of the 2017 campaign are likely to be avoided. The central government has also passed over responsibility for cuts in industrial production to meet environmental targets to local governments, partly because of the public backlash against what was then the central government's policy last year when coal heating was withdrawn before gas supplies had become available.

The medium-term objectives appear to remain unchanged, however, with pollution control remaining one of Xi Jinping's top three priorities for China until 2020.[33] At the end of 2017 the government increased the number of consumers who would have to switch to gas by 2021 and by 2019 it has said that cleaner fuels should represent 5% of heating demand in northern China and 70% by 2021. It forecasts that gas demand in the 28 worst-affected cities will rise by 23 bcm/year by 2021 at the expense of a decline in coal consumption of 150 mn tonnes.

The NOCs have set out plans to be better prepared for the 2018/19 winter. CNOOC plans to expand its existing storage capacity and build new capacity. All three major companies plan to build more connections between their long-distance pipeline networks so that shortages can be dealt with more quickly. Increased availability of offshore gas output and more pipelines to shore should also give the gas sector more supply flexibility.[34]

1.3 Infrastructure access

Introducing and increasing third-party access to gas infrastructure in China is a key element in China's gas reform process – indeed the separation of pipelines from the direct control of the NOCs is the key midstream reform in our view. The government's latest draft guidance for infrastructure access was released in August this year.[35] These new guidelines provide greater regulatory transparency for investors and new entrants and seem likely to have been prompted by the severe gas shortages last winter, which have persuaded all parties that change is needed if they are to be avoided in future.

Potential national pipeline company

In 2016 the government proposed reducing gas pipeline tariffs by capping the rate of return on those pipelines.[36] It also had plans to create a national pipeline company and open import terminals to third parties, breaking the grip on infrastructure that the three Chinese oil companies hold. With spot LNG prices then at relatively low levels, the government's view was that independent importers from the private sector could contract for cheaper spot gas and bring it into China through the newly-liberalized import terminals, which would bring prices down and stimulate demand.

However, these reforms have been consistently opposed by the state oil companies and have not moved very far. The head of the NEA has repeatedly said that they are about to be launched – but they have not been, essentially because of resistance from the oil companies and provincial governments, which often hold stakes in provincial gas distributors. There is no certainty that the

[32] Atmospheric Particulate Matter with a diameter less than 2.5 micrometers
[33] South China Morning Post 27 September 2018
[34] China Oil & Gas Reform Summit, cited in Natural Gas Daily 9 January 2018
[35] National Development and Reform Commission, cited in Natural Gas Daily 8 August 2018
http://www.ndrc.gov.cn/gzdt/201808/t20180803_895251.html
[36] Natural Gas Daily 27 February 2017

government would want to press the NOCs too hard – they are, after all, national champions, overseas investors for China, the government's source of industry knowledge and a critical link between government energy policies and final consumers.

By 2017 – three years after the government released guidelines promoting access – just eight independent companies had used LNG import facilities owned by the NOCs.[37] The NOCs control 90% of China's current 88 bcm/year LNG import terminal capacity, with the balance held by the second-tier importers such as ENN and Jovo Energy.[38] Average capacity utilization was 7% last year – even though some northern terminals operated above their official capacity during the winter. Some three-quarters of this capacity is in the south and east, while most of the winter demand is in the north of China, where in parts it can be ten times higher than summer demand.

By the middle of 2017 the government was reduced to restating a series of relatively vague reform plans. These included inviting competition in the upstream segment, separating the ownership of the pipeline network from the major oil companies and enforcing third-party access to that pipeline network as well as storage and import infrastructure. Few details of how this was to be achieved were revealed and there was no timescale for the process. Government officials highlighted that the proposals were only in outline and that more detailed plans were in the process of being drawn up. Pipeline ownership reform was cited as the first priority and indeed the major oil companies have established their own pipeline subsidiaries which, as and when the government's reform plans are implemented, could form the basis of independent pipeline companies. Early last year five of the companies released their pipeline business costs as they were instructed to do by the NDRC in 2016, with the aim of enabling the government to set more transparent transmission tariffs in the future. The most recent comments made have suggested that the 'national pipeline company' could be part-owned by the national oil companies, which would mean that careful regulation would be needed to ensure that the objective of transparent third party access to national infrastructure could be achieved.[39]

NOC attitudes to sector reform may be changing

However, in recent months there has been a change in attitude on the part of at least one of the NOCs. In July, CNOOC, the world's third-largest LNG importer, publicly announced that it would open up its LNG terminals to third parties.[40] It has been reluctant to allow this in the past because of concerns about losing market share to independents who could import spot LNG cargoes at prices below CNOOC's term contracts. Continued government pressure appears to now be having an impact on CNOOC, which may have concluded that TPA is inevitable and that it should prepare for it. In the past it had considered allowing TPA to its Tianjin floating storage and regasification unit but decided against it when it needed all the capacity for its own use in 2017. It is now reported to be offering slots at its terminals through the Shanghai Petroleum and Gas Exchange – although at high prices[41]. At least one transaction has taken place, in October, with Zhenhua Oil winning a September auction for capacity at CNOOC's Guangdong terminal.[42]

CNOOC also seems convinced that more gas suppliers are needed in the Chinese market to ensure that the burden of meeting China's growing gas demand is shared more equally. We should also note that it will take time to negotiate the various contracts needed to turn this proposal into reality and, even though CNOOC's terminals may allow third party access, access by those same new suppliers

[37] Natural Gas Daily 24 May 2017
[38] World Gas Intelligence 3 October 2018
[39] Liutong Zhang, WaterRock Energy Economics 12 August 2018
[40] Statement made by Jin Shuping of CNOOC at Shanghai launch of IEA Gas Market Outlook 2018, cited in Natural Gas Daily 23 July 2018
[41] World Gas Intelligence 3 October 2018
[42] Natural Gas Daily 15 October 2018

to the downstream pipelines taking gas to customers currently hard to come by but is equally important if the move is to be a success.

1.4 Upstream and downstream reform

The government has been criticized by the oil and gas industry for its cautious progress on sector reform.

In the upstream segment, exploration rights are held overwhelmingly by the major oil companies and the government has outlined plans to liberalize the licence allocation and ownership process. It tried this in Xinjiang in 2015 but with no success, although a 2018 tender[43] was more successful, with 7 bidders and 3 licences awarded.

In the downstream segment the government set a rate of return of 7% on urban gas distribution assets in the middle of 2017.[44] It had been initially discussing a rate of return cap on city gas distribution assets of just 6%. Draft proposals for Hubei province were released early in 2017[45] but faced considerable resistance from the entrenched city gas players and have not made much progress. The proposal was for a cap of 8% on the return from pipelines which use at least 75% of their capacity, in line with central government rules. Hubei went one step further, however, and proposed limiting returns on investments in gas distribution to 6%.[46] With existing margins higher than this, there has been resistance from the distribution companies. With the government also allowing large industrial users and power generators to negotiate directly with midstream suppliers (although progress has been relatively slow on this), these moves have threatened the cross-subsidy model used by the city gas companies in which profits from industrial users are used to subsidize prices to residential users.

At the beginning of September 2017 – at the same time as the reduction in citygate prices – the tariffs charged by 13 cross-regional pipeline companies were cut by 15% and the tariff-setting process was made more transparent. In addition, the rate of return proposals were implemented, with a rate of return of 8% allowed only on those pipelines which achieved a utilization rate of 75%.[47] This was designed to encourage the pipeline owners to allow third parties to access their pipelines with the overall aim of boosting gas use through lower costs.

1.5 Development of gas hubs

China has two gas hub projects underway, at Shanghai and Chongqing – either or both of which could create a pricing basis for gas in China.

China's ambition to create a gas hub in Shanghai as part of its gas sector reform process started in 2015 and has both national and international components. Domestically, a Shanghai gas hub would enable gas prices across China to be set with reference to an internationally traded benchmark price. Internationally it would reinforce China's influence in the world - energy and otherwise.

A second hub project is just getting underway in the city of Chongqing. The Chongqing Oil & Gas Exchange is aiming to provide a trading platform for LNG imports, pipeline imports and domestically produced gas[48] and would create a domestic pricing basis for gas.

For an effective gas hub to develop, a series of developments are needed to underpin it. These include competition between suppliers, third-party access to infrastructure, price transparency, standardized contracts and a liquid price index – as well as a government commitment not to

[43] Natural Gas Daily 20 December 2017
[44] Natural Gas Daily 23 June 2017
[45] Natural Gas Daily 15 March 2017
[46] Natural Gas Daily 5 June 2017
[47] Natural Gas Daily 6 September 2017
[48] Natural Gas Daily 6 March 2017

intervene in the market (as happened to the coal market in China in late 2016). The process of putting these conditions in place takes time and requires a clear commitment to the development of a free market in the gas sector.

Asian competition to be the regional gas hub is intensifying

With three-quarters of the world's LNG targeting Asia, competition to be a gas hub is intensifying.[49] China, Japan and Singapore have all launched plans to create gas hubs. Buyers in Asia want a hub that reflects the fundamentals of the Asian market. China argues that a hub in China is the logical choice because of the country's potential for massive gas demand, Shanghai's location and China's long history of both producing, and subsequently importing, gas. However, the Chinese gas industry continues to be dominated by the three state-owned oil companies and Chinese gas prices continue to be regulated to a greater or lesser degree, which presents challenges to the creation of an effective gas hub.

Japanese officials have been arguing that the physical location of a hub is less relevant than enhanced liquidity to enable trading to take place based on a representative index. US exporters contend that liquidity is the most important issue to enable a market hub to develop, although with so much LNG targeting Asia and increasingly being sold on a spot basis globally, liquidity ought not to be a serious concern – at least at first sight. It may be that spot market trading is too thin to allow an obvious gas hub to develop or that long-term contracts remain a major part of the LNG market. However, with LNG volumes and the proportion of spot trading set to rise, regional gas hubs are set to be a more important element in the global gas industry.

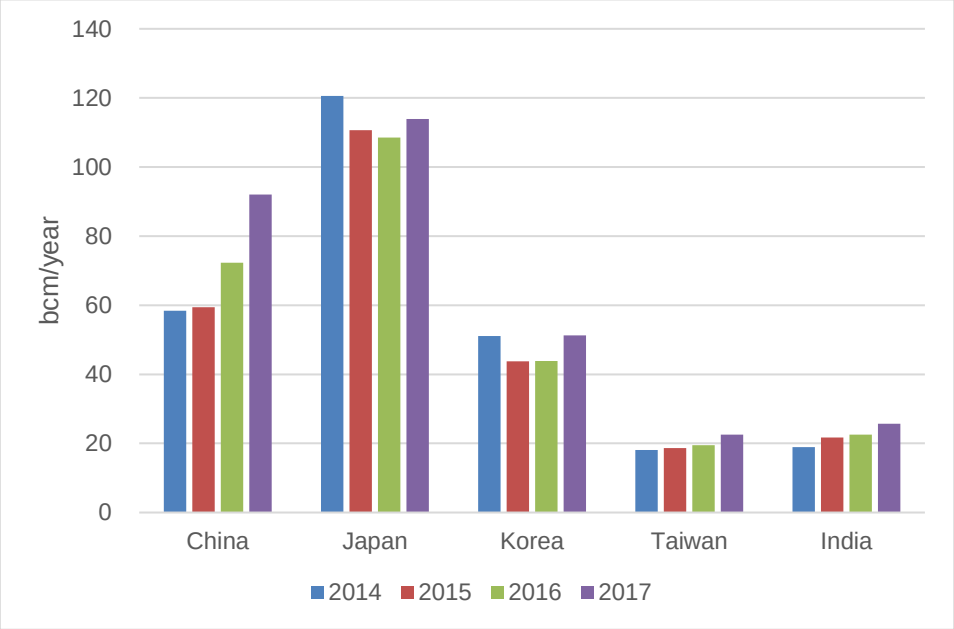
The NDRC has highlighted that China wants to move from being a price-taker to a role as a price-setter. It cites LNG sellers Qatar and Indonesia as having raised prices unreasonably when they were in a position to because of market conditions. In the view of the NDRC, a gas hub will increase China's influence on the Asian – and potentially global – gas market and protect China from what the NDRC sees as unreasonable price increases.

China's case to be a regional hub

China's total gas demand is almost twice that of Japan, five times greater than Korea's and sixteen times larger than Singapore's, which China suggests makes the case for a Chinese hub clear. Internationally, however, it is Japan that imports more gas – for now at least, since China's imports on a monthly basis in 2018 have started to exceed those of Japan in some months.[50] In 2017 Japan imported an estimated 111 bcm of gas (all as LNG) against total Chinese imports – by pipeline and as LNG of 93 bcm. Last year, Singaporean and Korean imports were considerably smaller and China overtook Korea as the world's second-largest importer of LNG (see Figure 5 for details). The IEA predicts[51] that 2019 will see China overtake Japan as the world's largest gas importer. By 2023 the IEA predicts that most Chinese imports will be in the form of LNG, although it is unlikely to become the world's largest LNG importer until 2028, according to the consultants Wood Mackenzie.[52] In terms of its overall impact on the global gas market, therefore, China is clearly set to grow in importance and influence.

[49] World Gas Intelligence 14 March 2018
[50] World Gas Intelligence 16 June 2018
[51] International Energy Agency Gas Market Report 2018
[52] Natural Gas Daily 3 January 2018

Figure 5: Asian gas import volumes, 2014–17



Source: BP Statistical Review 2018, World Gas Intelligence

China's import dependency is increasing as its demand grows because production, which rose by just 8.5% in 2017, is rising at just over half the level of demand growth (15% in 2017). Japan's demand is generally declining and with it the need for imports. Singapore may offer a more geographically advantageous location for a hub but with total ASEAN demand now only equivalent to 60% of China's demand and the latter growing much more strongly, China's case for the hub to be based at Shanghai or Chongqing is strong. If China's gas price reform is carried through to its logical conclusion of market-based pricing and a more transparent domestic industry framework, this would clearly bolster the country's case further.

Chinese officials predict the end of oil-linked pricing in Asia because of the growing gas surplus. They go one step further and suggest the end of US dollar-denominated oil prices in Asian gas pricing, preferring to see the role of the RMB expanded to replace the dollar where oil has a role to play at all. Chinese officials argue that Shanghai's location on the east coast of China, among the energy-intensive coastal provinces where demand is growing particularly strongly, coupled with the growing number of LNG import terminals and pipeline connections to regional gas suppliers, are competitive strengths of a Shanghai-based gas hub. Similarly for Chongqing, which is located in a gas producing region of the country with good connections to import terminals and pipelines.

1.6 The challenge from renewables

There is a growing realization on the part of many in China's gas sector that there is a limited window of opportunity for gas to establish itself as a major source of energy in China. With gas representing around 6.6% of total energy consumption in 2017,[53] it faces a challenge over the next decade to grow to represent a sufficiently large share of total energy consumption such that it retains its place at the table when the government considers China's overall national energy policy.

[53] BP Statistical Review of World Energy 2018

Longer-term focus on ensuring that gas does not get marginalized as a fuel because of pricing

CNPC management also highlighted this concern at a recent conference in Beijing noting that if gas failed to become a mainstream energy source in the next ten to fifteen years, then it would likely be replaced by renewables in the same way that coal and oil were in the process of being replaced. So the strong growth that we have seen in Chinese gas demand in 2017 and the current supportive environment, driven by China's coal-to-gas switching programme, may be only transitory – a view expressed earlier by industry observers when gas was described as 'a bridge fuel' towards what would be a renewable energy future for China.

Other industry participants are less concerned about the future of gas in China – noting their belief that fossil fuels will remain a dominant fuel source globally for at least the next thirty years.

Renewables are a serious long-term threat to gas

Overall we do see a threat to the longer-term future for gas in China because renewables – such as solar photo-voltaics and lithium battery storage - will, based on current progress, likely end up cheaper than gas and be less polluting even than low-carbon gas, particularly if subsidies are included. Gas industry players note that Beijing provides many more price subsidies to renewable power generation than it does to gas-fired power generation, where only a few local governments provide subsidies.[54] Initially we see renewables replacing coal and perhaps transport fuels through electricity but longer-term there must be a challenge to gas in the industrial sector and power generation from the ongoing development of renewables as well as China's ambitious nuclear programme.

The one caveat that we would add here is that China's future energy needs are so large, and the need to reduce carbon emissions so urgent, that a multiplicity of energy sources are likely to be needed to meet the demand – fossil fuels, renewables and nuclear energy – and this could well provide a longer lifespan for natural gas in China's energy landscape than some have suggested. Most of the analysis and forecasting conducted by international energy organizations does actually foresee at least twenty, if not thirty, years of rising gas demand in China.[55, 56, 57]

[54] World Gas Intelligence 20 June 2018
[55] International Energy Agency World Energy Outlook 2017 (Sustainable Development Scenario), p452
[56] International Energy Agency World Energy Outlook 2017 (New Policies Scenario), p 511
[57] US Energy Information Administration International Energy Outlook 2017
https://www.eia.gov/outlooks/aeo/data/browser/#/?id=6-IEO2017&sourcekey=0

2. The need for gas price reform in China

This section addresses the need for gas price reform in China. We identify and discuss the three key reasons why price reform is essential in China (challenged industry profitability, a relatively weak production outlook and China's growing import dependency).

2.1 Overview

The key dilemma in China is that lower gas prices are needed to encourage gas demand, replace coal with gas and improve the environment, while higher prices are needed to stimulate investment and supply. The government's policy in this regard is unclear, since it has two constituencies to satisfy. The longer-term goal seems focused on balancing the interests of both producers and consumers while slowly introducing more market-related pricing to China's gas sector.

Need to fund rising volumes of expensive imports

Historically, one of the key reasons for price reform has been the growing mismatch between China's domestic production and its gas consumption – leading to increasing dependence on expensive imports of LNG and pipeline gas, which can only be sold at a loss at current domestic prices.

China's gas production has been steadily rising since the mid-1980s with the rate of increase picking up in the mid-2000s. In 2017 it stood at 148 bcm/year, an increase of 8.5%[58] against 2016 and more than double the level of ten years ago, making it the sixth-largest gas producer in the world with more than 70% of output coming from conventional sources.[59] The National Energy Administration is targeting a 7.6% increase in gas output in 2018 – taking it to 160 bcm/year or 7.5% of China's total energy supply.[60]

Optimistic production forecasts by international agencies

A number of international agencies have recently published their medium-term outlooks for Chinese gas production. The International Energy Agency has forecast that output – both conventional and unconventional - will grow at an average rate of 3.8% a year between now and 2040, reaching 261 bcm/year in 2030 and 336 bcm/year in 2040.[61] The US Energy Information Administration has a slightly different but still optimistic outlook, forecasting output of 246 bcm/year by 2030, 400 bcm/year by 2040 and 585 bcm/year by 2050.[62] Much of the difference in the two outlooks can be put down to differing opinions on the outlook for China's shale gas production, where the US EIA has a forecast that is twice as large as that of the IEA (it should be noted that the IEA's forecast also assumes strong increases in unconventional gas output and previous forecasts by many observers have been proven in hindsight to be overly optimistic). To put this in context, the Chinese government's 2020 production target for shale gas is 30 bcm/year[63] although the consultants Wood Mackenzie have suggested 17 bcm/year may be more realistic[64] while PetroChina's own target is for its shale gas output to be 10 bcm in 2020[65] (against its 2017 output of around 3 bcm). Total 2017 shale gas output in China was just 9 bcm and output has typically fallen short of government-set targets in the past.

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[58] National Development and Reform Commission, cited in Natural Gas Daily 1 February 2018 http://yxj.ndrc.gov.cn/mtzhgl/201801/t20180131_876378.html
[59] International Energy Agency Gas Market Report 2018
[60] Natural Gas Daily 8 March 2018
[61] International Energy Agency World Energy Outlook 2017
[62] Energy Information Administration International Energy Outlook 2017
[63] National Energy Administration 2016 Development Plan, cited in Caixing 27 June 2018
[64] Wood Mackenzie, cited in Caixing 27 June 2018
[65] Xinhua, cited by Reuters 26 January 2017

Consumption growing even more rapidly

Gas consumption, however, has been rising even more quickly than production. In the last ten years it has more than trebled – rising to 237 bcm/year in 2017.[66] For a long time the availability of gas to China was a significant constraint on the country's level of gas demand. However by the mid-2000s, when LNG started to arrive, that constraint was lifted. Imports – of both LNG and pipeline gas - have grown over time to a point where China's import dependency was 39% in 2017 and is set to move higher in the years ahead.

The underlying rationale for gas price reform can therefore be divided into three areas:

- Industry profitability
- Production outlook
- Import dependency.

2.2 Industry profitability

The rising volume and cost of imports was one of the key drivers prompting gas price reform in China. The major importers (the national oil companies) faced significant and growing losses as import prices rose sharply between 2007 and 2014. Hence it became steadily more urgent that prices inside the country became more closely linked with the prices that China was paying for the increasing volumes of gas that it was importing. Continuing to consume gas priced domestically at regulated low prices but supplied by imports at market prices was becoming unsustainable.

Chinese oil companies lobbied for higher prices

The Chinese oil companies were incurring losses on all their imports, which they made no secret about despite the tax subsidies.[67] Using their extensive government connections, they undoubtedly lobbied government for domestic gas price reform. This reform was not only economically sensible for China but also financially necessary to avoid draining the finances of both the oil companies and the country.

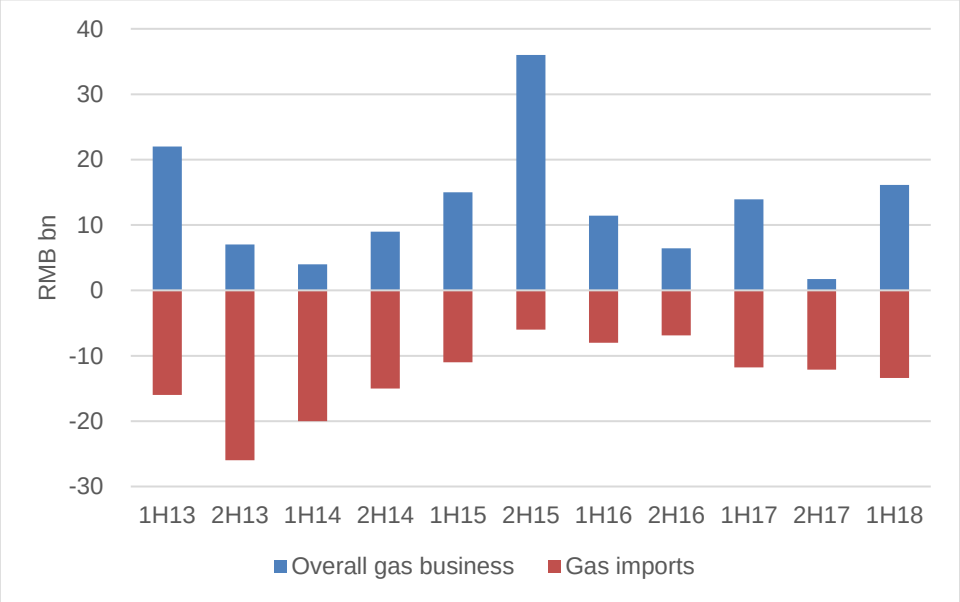
As global oil prices declined from 2013, further eroding the companies' overall profitability, the need for gas price reform to stem the losses grew in importance. Unsurprisingly, in both 2013 and 2014 domestic gas prices were increased as a way of stemming these losses - despite the fact that import prices were actually then at their peak and began their lagged oil price-linked decline in 2014.

Gas imports remain lossmaking

PetroChina continues to lose money on its domestic sales of imported gas.[68] The company's results for 2017 showed a loss of RMB23.9 bn ($3.8bn) on sales of imported gas in the domestic market, a 60% increase on 2016, which the company highlighted as being caused by higher volumes and higher oil prices.[69] In the first half of 2018, PetroChina's reported loss on gas imports was RMB13.4 bn ($2.1 bn).[70] Figure 6 below (based on data from PetroChina's Natural Gas & Pipeline segment) shows how consistently unprofitable the import of gas has been for the company while its overall gas business has actually been profitable. The company has some relatively expensive term LNG contracts in its portfolio making the spot LNG market increasingly attractive.

[66] National Development and Reform Commission, cited in Natural Gas Daily 1 February 2018 http://yxj.ndrc.gov.cn/mtzhgl/201801/t20180131_876378.html
[67] World Gas Intelligence 25 April 2018
[68] PetroChina Annual Report 2017
[69] Natural Gas Daily 4 April 2018
[70] PetroChina Interim Report 2018

Figure 6: PetroChina gas business profitability, 2013–2018



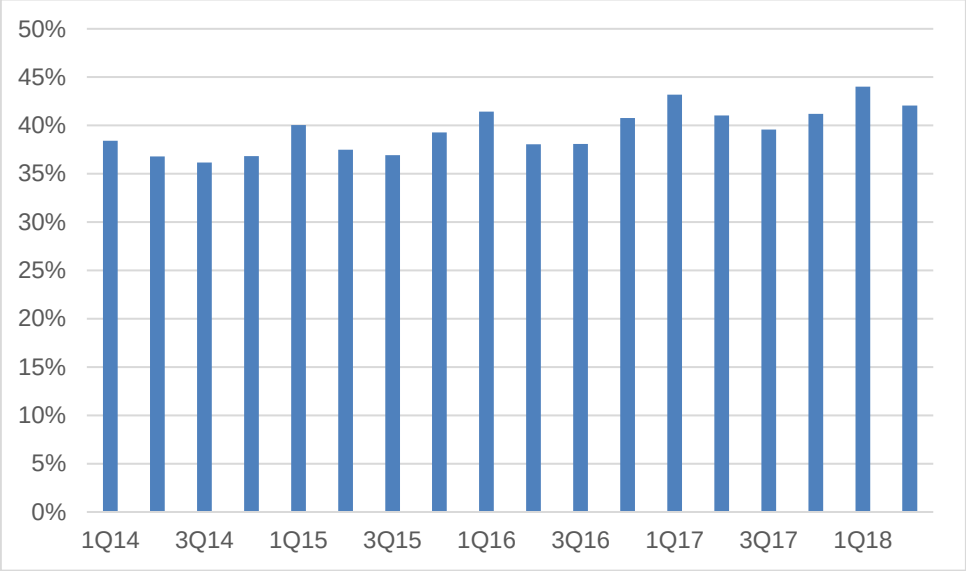
Source: PetroChina Annual, Interim and Quarterly Reports

Increasing NOC focus on profitable domestic gas production

In terms of company strategy, PetroChina's output is growing more focused on gas production than in the past (see Figure 7 below). This is a common trend across major energy companies since gas demand is growing more quickly than oil demand and there is a broader structural shift underway to lower-carbon fuels. In PetroChina's case we believe it is also partly to support government policies for a cleaner energy mix and the resulting strong increase in gas demand. Xi Jinping is reported to have told the Chinese NOCs that they should 'help safeguard the country's national energy security' by increasing output to cut China's dependence on imports.[71] In 2017, PetroChina's domestic gas output rose by 5% while oil output declined by 3% against the 2016 level.[72] Gas represented 41% of total hydrocarbon output in 2017, compared to 40% in 2016 and in 1H18 it reached 43%.[73] During 2018 PetroChina aims to increase its gas production by 5% and then at 4-5%/year over the next five years.[74] In contrast it expects its oil output to rise by just 0.1%.[75] The company wants gas to account for half its output by 2020 while gas already represents 50% of its hydrocarbon reserves. Longer-term, PetroChina's latest corporate social responsibility report targets gas to represent 55% of output by 2030.[76]

[71] Xi Jinping, cited in Natural Gas Daily 3 September 2018
[72] PetroChina Annual Report 2017
[73] PetroChina Interim Report 2018
[74] PetroChina 1H18 Financial Report, cited in Natural Gas Daily 3 September 2018
[75] Natural Gas Daily 4 April 2018
[76] PetroChina Corporate Social Responsibility Report 2018, cited in Natural Gas Daily 7 June 2018

Figure 7: Gas output share of production for PetroChina, 2014-2018



Source: PetroChina Annual, Interim and Quarterly Reports

Sinopec's latest annual figures similarly show that in 2017 oil output fell by 2% while gas production rose by 19%.[77] Gas represented 38% of total output in 2017 compared to 34% in 2016. The company increased gas output by 5.3% in 1H18 and is aiming to produce 6.7% more gas overall in 2018 compared to 2017.[78]

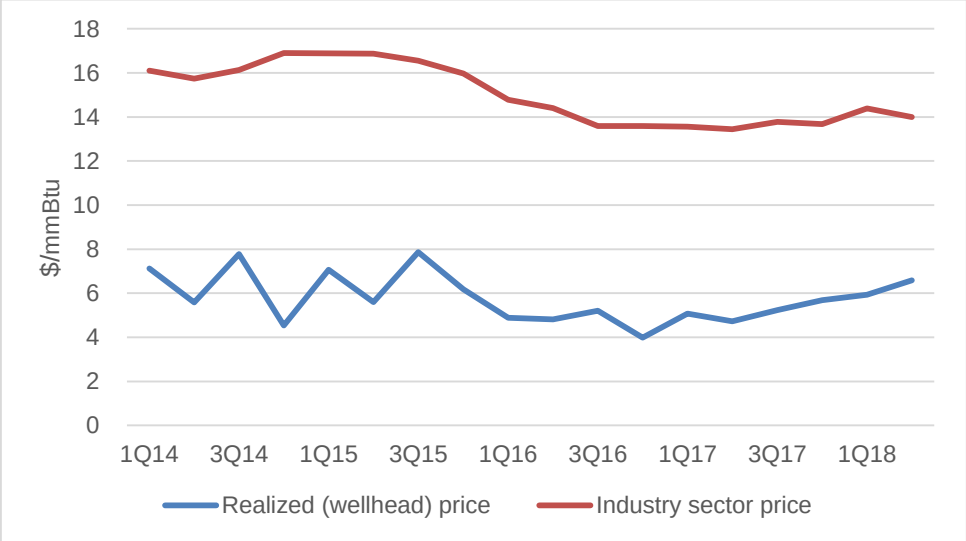
CNOOC similarly favours more gas in its production portfolio.[79] Its gas output grew more than 12% in the first half of 2018[80] and it aims to increase its gas reserves by 50% between now and 2025 to help meet China's gas demand.

Domestic gas production remains profitable at current prices

Most gas used in China is still produced domestically, rather than imported. The chart below compares what PetroChina describes as the 'realized price' with the industrial sector citygate price from the NDRC.[81] If we take PetroChina's realized price as a proxy for the wellhead price, broadly the two prices do move in line with each other. The industrial price is the price which, despite its limitations, is the most influenced by the international market through the pricing formula. The formula, and its operation, is discussed in detail on page 39. The key point to note at this stage, however, is that the formula is an influence on the government's price-setting process, which typically has significant delays and unpredictable outcomes. Despite this it remains a useful proxy for end-user prices in China and Figure 8 below shows quarterly averages of the industrial price in line with the realized (wellhead) price data provided by PetroChina in its quarterly financial reports.

[77] Sinopec Annual Report 2017
[78] Sinopec Interim Report 2018 http://www.sinopec.com/listco/en/Resource/Pdf/2018082619.pdf
[79] Natural Gas Daily 29 August 2017
[80] CNOOC Mid-Year Review 2018 http://ltd.cnooc.com.cn/attach/0/1808231643540301881.pdf
[81] National Development and Reform Commission, sourced from CEIC

Figure 8: Quarterly gas price movements, 2014–2018



Source: PetroChina, NDRC

Overall gas production business consistently profitable, despite import losses

From PetroChina's financial results we can see that the company's overall gas business has been consistently profitable (Figure 6 above) – meaning that its domestic gas business has been even more profitable, since it has had to subsidize the loss-making gas import side of the business. However, the profitability of the company's domestic gas business has declined from RMB71 bn ($11.5 bn) in 2013 to just RMB40 bn ($5.9 bn) in 2017, although it recovered to RMB 30 bn ($4.6 bn) in 1H18.

Although LNG prices are on the rise again, there has so far been little impact on demand because of the continued support for coal to gas switching. However the NOCs have been complaining that they continue to lose money on domestic sales of imported gas because citygate prices are kept low to boost demand[82] and with most term LNG contracts linked to oil, importers are concerned about losing market share to cheaper pipeline gas or even domestic output. Industry observers have suggested that pipeline imports and conventional gas production cost around RMB2/cm ($8.90/mmBtu), with even offshore gas costing around RMB1.50/cm ($6.70/mmBtu) against LNG imports costing more than RMB2/cm ($8.93/mmBtu). That said, the consensus remains that the Chinese NOCs will continue to buy LNG through 2018 despite the losses, with the aim of keeping the central government happy. While the NOCs receive an import tax rebate (11% of the difference between the actual price and the government-set reference price)[83] for losses they make on sales of imported LNG, some of their losses are passed downstream to the local gas distributors who were promised guaranteed supply for the 2018/19 winter if they took loss-making volumes in the low-demand spring/summer season.

2.3 Production outlook

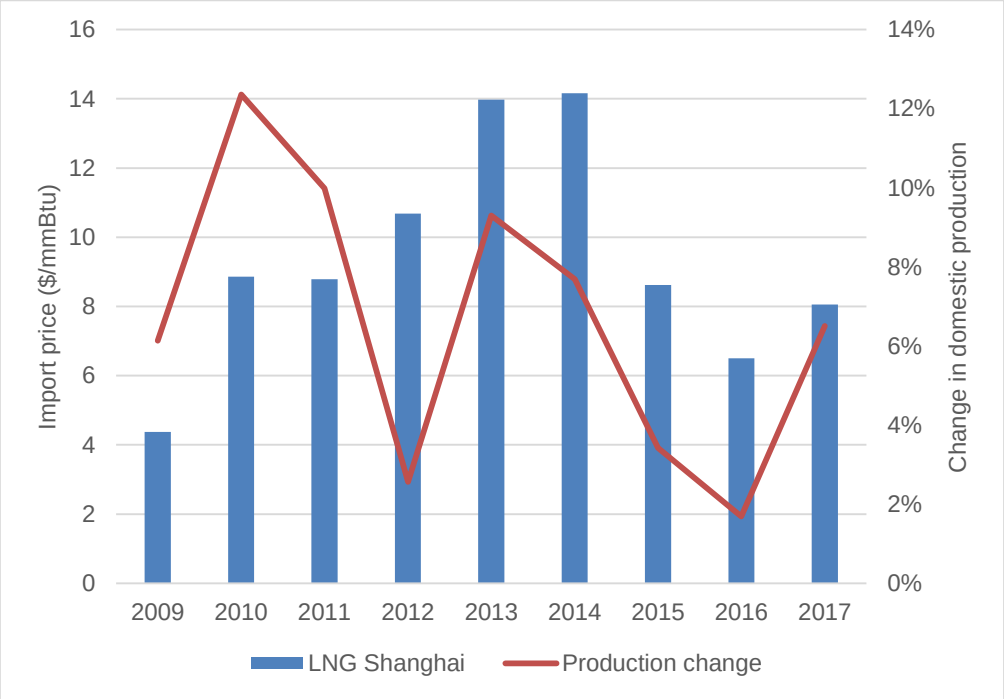
Gas pricing has a significant impact on the outlook for gas production

Pricing is also an important element of the outlook for gas production, which is a key element of Chinese energy policy, particularly given the rising level of gas import dependency.

[82] CNPC, Sinopec and CNOOC, cited in World Gas Intelligence 25 April 2018
[83] Reuters 30 January 2018

In the past, when domestic prices were low and set by the government without reference to international prices, the NOCs' interest in growing domestic output (particularly given the Chinese government's focus on more difficult-to-extract, and hence more costly, shale gas) waned. When international gas prices were high, and with it Chinese import prices, domestic output ought to have looked more attractive to the gas companies which are largely responsible both for production and for imports. Comparing changes in the price of delivered LNG to Shanghai with production changes (Figure 9 below), there does seem to be some modest correlation between rising international prices and changes in domestic output over the past few years, albeit often with a time lag.

Figure 9: Gas production change vs LNG import price, 2009–2017



Source: NDRC

Policy of low end-user prices puts pressure on profitability

With the government's aim of increasing the use of natural gas in the economy and lower prices seen as a key driver of higher gas use, supply is likely to face pressures because of reduced profitability. In the pre-reform era, the end-user price was based on the wellhead price plus regulated costs for the various pipelines and distribution infrastructure that the gas passed through on its way to the end-user. At that time the government set the wellhead price based on operating costs and an allowed rate of return.

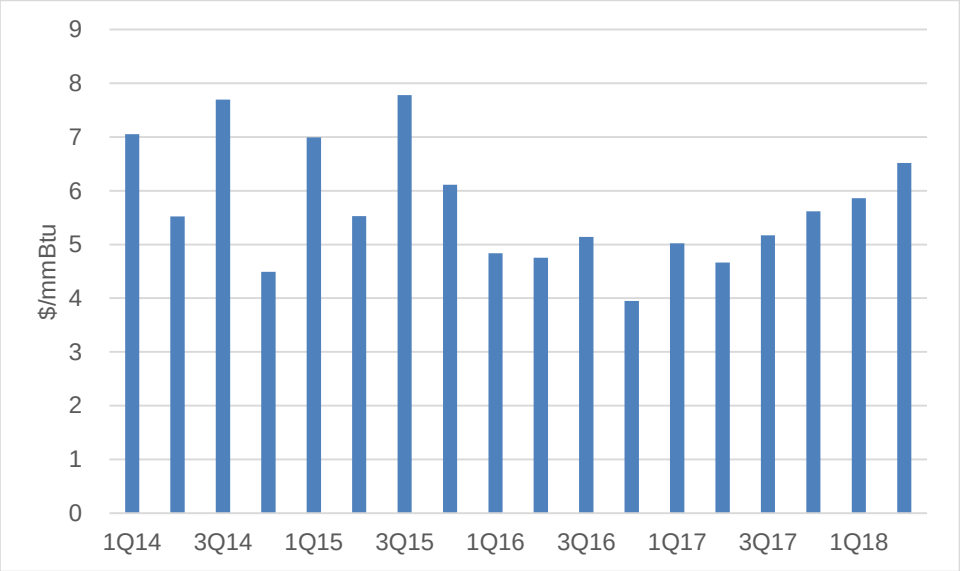
In the new world – and as we assess later, we are on the way to this new world but not yet there – citygate (or wholesale) prices are influenced, to some modest degree at least, by the market and the wellhead price is notionally derived from it, with the deduction of regulated pipeline and distribution infrastructure costs. It has become in effect a netback price rather than a pure wellhead price. In the medium-term, and if the planned reforms are fully implemented, the government's ability to set the wellhead price at a level that is attractive to the NOCs such that they would want to increase gas production, is much more limited.

After a long decline, 'realized' prices have been rising over the last eighteen months

Using PetroChina's published accounts, we have analyzed the achieved price for wellhead gas over the past four and a half years and shown it in Figure 10 below in $/mmBtu for comparability with other prices. There appears to have been broadly a steady decline (albeit with considerable variability) in prices over three of the last four years, although the last twelve to eighteen months have shown a

steady increase. The citygate price was cut by the NDRC in September 2017 yet the realized wellhead price has increased according to PetroChina's published data. We ascribe this to the sharply rising demand for gas in China – not all of which is sold at the NDRC regulated prices – along with tighter regulation of midstream costs through a lower permitted rate of return.

Figure 10: PetroChina 'realized'/wellhead price, 2014–2018



Source: PetroChina Annual, Interim and Quarterly Reports

Conflict between pricing to increase demand or to reduce import dependency

Hence we conclude that the government's desire for lower end-user gas prices to stimulate demand for gas is likely to have a negative influence on China's domestic gas output. Production was 148 bcm in 2017[84] and the National Energy Administration wants it to grow by 7.6% in 2018[85] to 160 bcm. However, the actual first half outturn was an increase of just 4.6% to 77.5 bcm.[86] The one factor arguing against this – and it remains unclear just how important this is to China and whether it can be adequately resolved by diversity of both suppliers and supply routes– is the country's increasing dependence on imported LNG and pipeline gas. While this might have been acceptable – certainly for oil - in less confrontational times, the Chinese government may begin to place an even greater focus on raising output to reduce the country's dependency on imported gas which could have implications for the NOCs themselves and for the development of gas prices in China.

The State Council released a document in September 2018 which forecast output of 200 bcm in 2020.[87] Reaching 200 bcm/year of output within three years is going to be a challenge. It implies an annual growth rate in excess of 10% but growth in the first nine months of this year has been just 6.2%.[88] PetroChina, the country's largest gas producer, recently published its output plans which call for annual increases of just 4-5% over the next few years.[89]

[84] National Development and Reform Commission, cited in Natural Gas Daily 1 February 2018 http://yxj.ndrc.gov.cn/mtzhgl/201801/t20180131_876378.html
[85] Natural Gas Daily 8 March 2018, 12 September 2018,
[86] National Bureau of Statistics, cited in Natural Gas Daily 16 July 2018 http://www.stats.gov.cn/tjsj/zxfb/201807/t20180716_1609877.html
[87] Natural Gas Daily 6 September 2018 http://www.gov.cn/zhengce/content/2018-09/05/content_5319419.htm
[88] National Bureau of Statistics, cited in Natural Gas Daily 19 October 2018 http://www.stats.gov.cn/tjsj/zxfb/201810/t20181019_1628640.html
[89] Natural Gas Daily 12 September 2018

2.4 Import dependency

China only began to import gas, initially as LNG, in 2006. By 2010 seaborne imports had been joined by pipeline gas from Central Asia (and from Myanmar in 2014). As Chinese demand has increasingly outstripped domestic production, imports have grown to play a steadily more important role in China's gas sector. Pricing has had a role to play in this but rising GDP, industrialization and urbanization have also contributed to the increased energy and gas use.

Steadily rising import dependency prompts concern

When imports began more than a decade ago they represented just 2% of Chinese demand in the first year.[90] In 2017 annual import dependency rose to 39.4%[91] with gas supplying 6.6% of China's energy (against 5.9% in 2016).[92] CNPC is forecasting that the 40% import dependency level will be breached this year – despite its below-consensus view that demand growth will slow markedly – and data for the first eight months of the year suggest that import dependency was 43.7% in the period.[93] This level of dependency looks set to rise further in the years ahead as China is targeting gas to supply 7.5% of total energy consumption this year, between 8.3-10% by 2020 and 15% by 2030. With the government's recently stated production target for 2020 of 200 bcma and a consumption target of as much as 360 bcma, annualized import dependency in 2020 could reach 44%.[94]

Having said that, there are reports that China's NOCs have not contracted enough LNG to meet a 10% target for gas as a proportion of total Chinese energy demand in 2020.[95] PetroChina has recently suggested that import dependency would reach only 40% by 2030[96] - although the company has a tendency to downplay estimates of import requirements to avoid alerting sellers to China's real needs which could lead to the country paying higher prices. The most recent IEA forecasts[97] suggest that import dependency will reach 48% by 2040. The US Energy Information Administration, on the other hand, forecasts a seemingly low level of import dependency of just 32% in 2030. To put dependency on imported gas in context, in 2017 oil (crude oil and products combined) import dependency rose to 71% from 67% in 2016.[98] In one sense this might suggest that gas imports could rise further without too much concern. On the other hand the external political environment may well have changed in the last year, making rising dependency on imported gas less politically acceptable.

An increase in import dependency from 39% in 2017 to 48% in 2040 as forecast by the IEA looks, on the face of it, relatively modest given China's rising gas demand. The IEA's forecast of increased domestic gas production, which slows the rise in import dependency, is predicated largely on a significant increase in China's unconventional gas production. In the IEA's New Policies Scenario conventional output is forecast to increase at a CAGR of just 0.5% between 2016 and 2040. Unconventional gas output, on the other hand, is forecast to rise at a CAGR of 7.7% and be around two-thirds of China's gas production by 2040.[99] Growth in shale gas output is the major driver, but synthetic natural gas, tight gas and coal bed methane also contribute to the rise in unconventional production.

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[90] Chen (2014)
[91] Liu Xiaoli Energy Research Institute of the National Development and Reform Commission, cited in Natural Gas Daily 9 July 2018
[92] BP Statistical Review of World Energy 2016 & 2017
[93] National Development and Reform Commission, cited in Natural Gas Daily 1 October 2018 http://yxj.ndrc.gov.cn/mtzhgl/201809/t20180930_899987.html
[94] Natural Gas Daily 12 September 2018
[95] World Gas Intelligence 26 September 2018
[96] Zou Caineng, PetroChina Research Institute of Petroleum Exploration and Development, cited in Natural Gas Daily 18 September 2018
[97] International Energy Agency World Energy Outlook 2017
[98] BP Statistical Review of World Energy 2018
[99] International Energy Agency World Energy Outlook 2017

Unconventional gas production will not be the answer

Past forecasts of unconventional gas production growth have proved overoptimistic and as a result we need to be somewhat cautious about placing too much reliance on them. China failed to meet its own shale gas production target of 6.5 bcm in 2015 although the 2016 total of 7.9 bcm[100] was a positive outturn. The 9 bcm produced in 2017 was less than the 15 bcm that the industry had targeted.[101] The next major target is 30 bcm/year by 2020 (which was itself reduced from an original target of 60-100 bcm/year).[102] However the consultants Wood Mackenzie forecast output in 2030 at just 17 bcm[103] despite declines in overall shale development costs, while Bernstein Research predict a slightly more optimistic total of 24 bcm/year in 2020.[104]

While the cost of shale wells appears to be declining, the government has been sending mixed messages on support for the industry. In 2015 the Ministry of Finance announced a cut in subsidies for shale gas production (currently RMB0.30/cm but declining to RMB0.20/cm in 2019-20) with no guarantee of support beyond 2020.[105] On the other hand, in April 2018 it reduced the resource tax on shale output from 6% to 4.2% for three years.[106] Most recently, in September 2018, it announced that it was considering extending the life of the subsidy on shale gas and coal bed methane through the next Five Year Plan (2021-25) and potentially expanding it to cover tight gas (which represents almost a quarter of domestic output) as well.

Government faces a strategic challenge on import dependency

However, if the more optimistic forecasts for unconventional gas production do prove to be correct, import dependency will rise to a level that the government can probably accept. If they prove to be as overly optimistic as previous forecasts have turned out to be, import dependency could rise to a level greater than the government can tolerate and it may be forced to take corrective action. There is a view on the part of some of China's energy industry that the country has plenty of gas and that there is no need to rely on outside suppliers for energy imports.[107] The domestic gas business is certainly profitable based on the figures that have been released by PetroChina. These suggest that if China did want to increase domestic production, theoretically it could do so even if this reduced the profitability of the national oil companies because of the higher production costs which may be needed to produce additional volumes. On the other hand, we can assume that with domestic gas production being profitable and gas imports being unprofitable, the companies are already maximizing domestic output. To go further would likely be sub-optimal and would only be undertaken to support government policy. Whether the government would sanction higher end-user gas prices to help achieve this objective is debatable. The argument against it is that the broader objective of pollution control – still a priority of Xi Jinping – would be compromised by rising prices, even if these were in support of broader external policy objectives.

Indeed there are already signs of a greater awareness of this issue on the part of the government. The Ministry of Land & Resources (MLR) has proposed that import dependency should be limited to no more than 50% by 2035 after having previously forecast import dependency of 52% being reached by 2045.[108] The MLR has an axe to grind in terms of stimulating domestic production and a 50% cap does not necessarily look unachievable if unconventional production grows as the IEA predicts.

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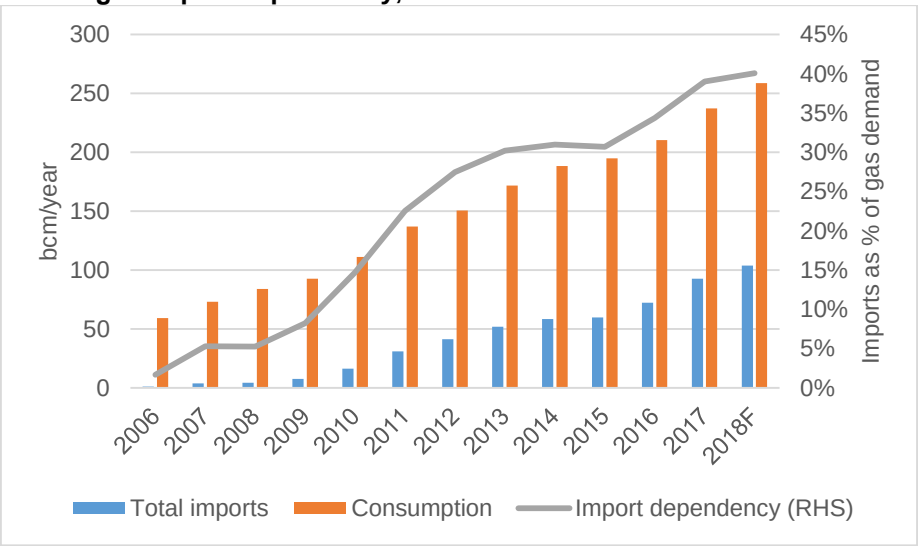
[100] Ministry of Land and Resources, cited in Newsbase.com 12 February 2018
[101] Ministry of Land and Resources, cited in Natural Gas Daily 17 September 2014
[102] Wu Xinxiong National Energy Administration, cited in Reuters 7 August 2014
[103] Woodmac.com 17 April 2018
[104] Bernstein Research, cited in Natural Gas Daily 11 June 2018
[105] Ministry of Finance, cited in Financial Times 29 April 2015.
[106] Natural Gas Daily 3 April 2018
[107] Discussion with energy analysts in China March 2018
[108] Natural Gas Daily 21 August 2017 and 4 December 2017

Nevertheless it is likely that these concerns over China's steadily increasing import dependency will increasingly be heard in the future.

Figure 11: China's gas import dependency, 2006–2018F

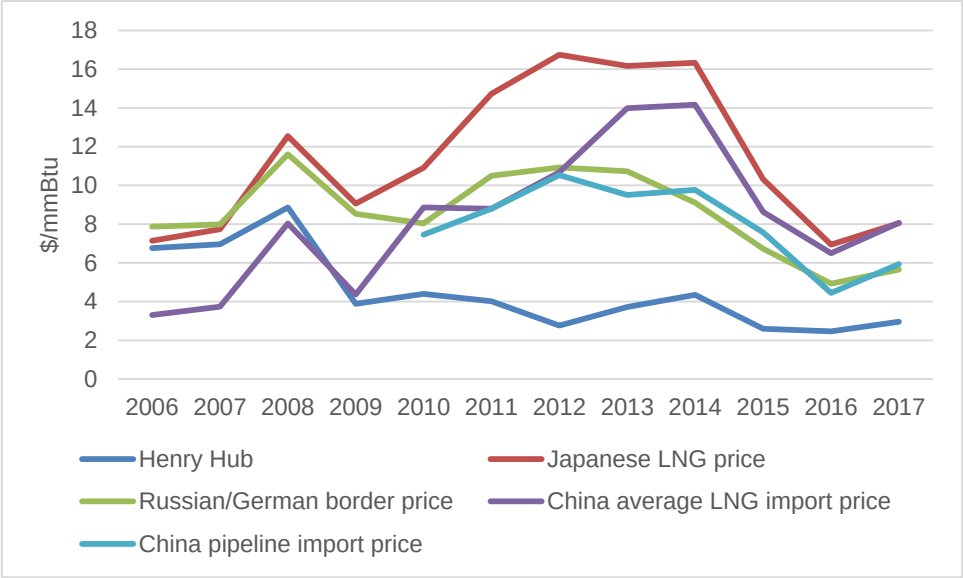


Source: BP Statistical Review of World Energy 2018, NDRC, TS Lombard

China's LNG import costs higher than pipeline gas costs

Figure 12 below shows the Chinese import price (for both LNG and pipeline gas) against a range of regional benchmarks since China began importing gas from mid-2006. Broadly, China's LNG import costs have moved in line with international markets – unsurprisingly since LNG is now a globally traded commodity and the Chinese oil companies are active participants in that market. Pipeline gas prices (from Central Asia and Myanmar) have also moved in line with international prices – although in recent years prices for LNG appear to have settled at slightly higher levels than pipeline gas prices – perhaps reflecting China's increased reliance on LNG imports to feed demand and its greater bargaining power as the only gas consumer at the end of the pipeline from Central Asia.

Figure 12: Chinese imports vs international prices, 2006–2017

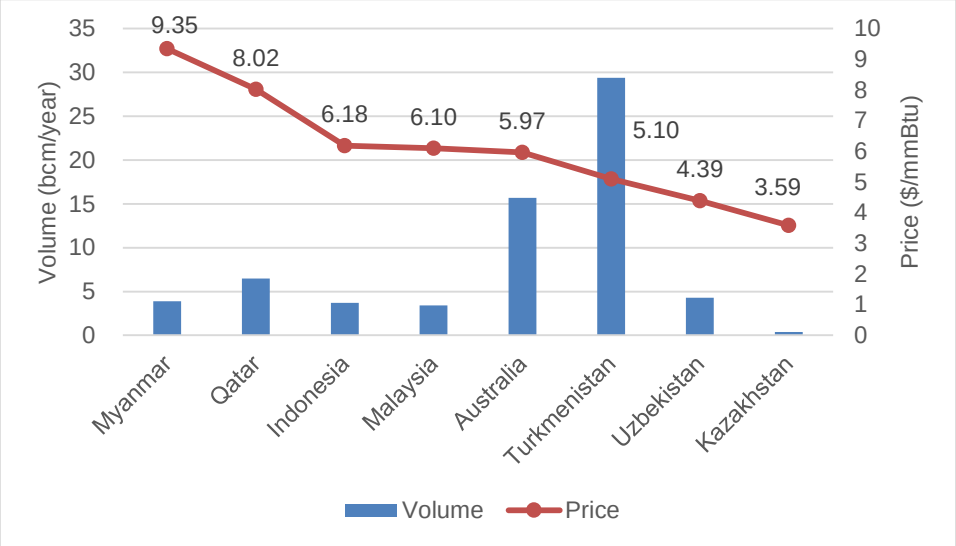


Source: BP Statistical Review of World Energy 2018, WGI, Argus, Natural Gas Daily, Chen (2014), TS Lombard

China has a broad range of LNG suppliers – reducing the risks

Figure 13 illustrates the wide range of countries involved in supplying gas to China, four pipeline suppliers and fifteen LNG suppliers in 2016 (only the four most important of the latter are shown)[109] and that number expanded further in 2017.[110] There are a wide range of prices at which China sources its gas imports. Once regasification, long-distance and regional pipeline transportation costs are added to the gas import costs, sales of gas at regulated prices are loss-making for the Chinese oil companies.

Figure 13: Chinese total import volumes and pricing, 2016



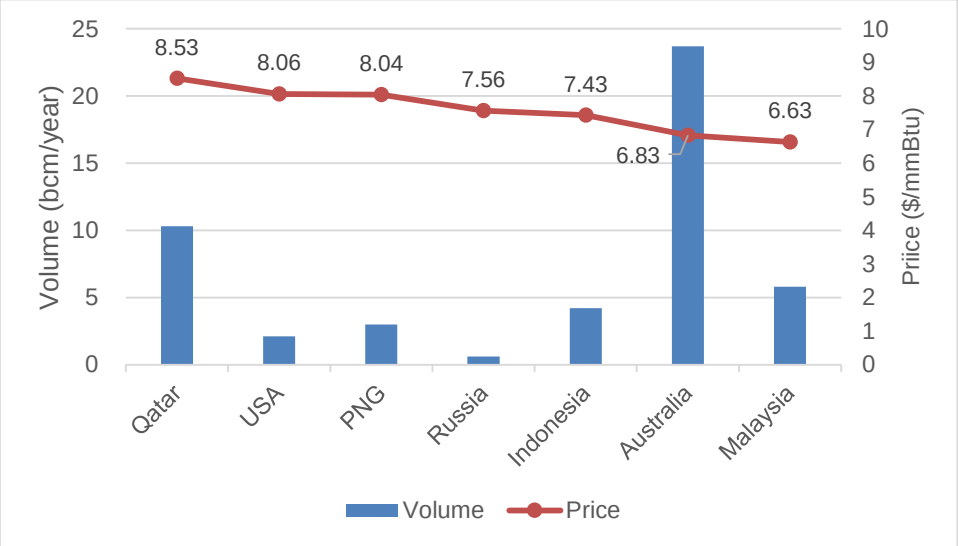
Source: BP Statistical Review of World Energy 2018, World Gas Intelligence, www.haiguan.info

Import costs have been steadily rising

Figure 14 shows the major LNG suppliers to China in 2017 along with the prices charged. Without exception, all the countries where there is comparable data raised their LNG prices to China (and other gas buyers) in 2017 compared to 2016, reflecting the higher oil price environment (2017 prices were almost 25% higher than those in 2016)[111] as well as China's demand for LNG imports in the second half of 2017, when it was the largest component of global LNG demand growth.[112]

[109] BP Statistical Review of World Energy 2017
[110] BP Statistical Review of World Energy 2018
[111] BP Statistical Review of World Energy 2018
[112] BP Statistical Review of World Energy 2018

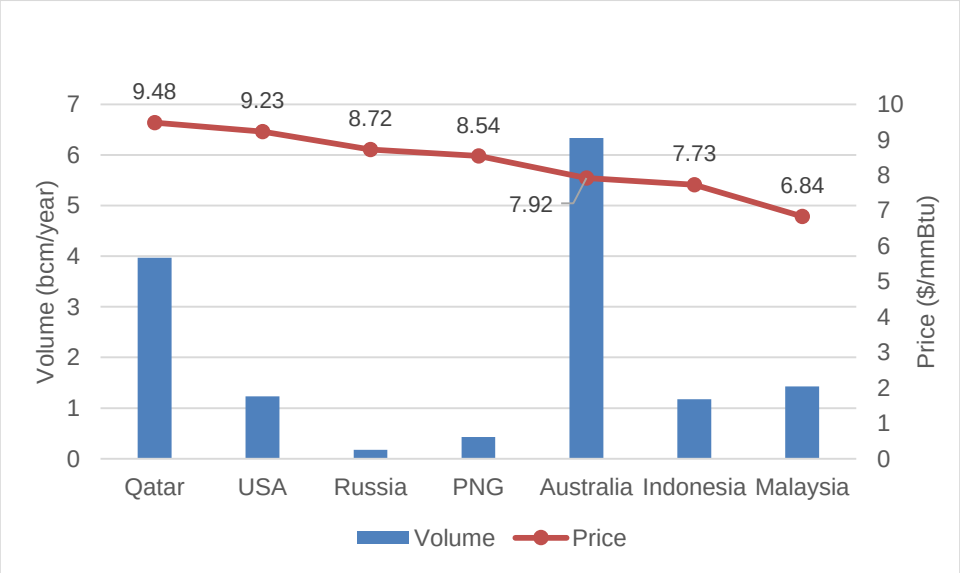
Figure 14: Chinese LNG import volumes and pricing, 2017



Source: BP Statistical Review of World Energy 2018, World Gas Intelligence

The price increases have continued into the first half of 2018 (Figure 15 below). Based on the data available, all of the major LNG suppliers have achieved higher prices in 1H18 than they did in 2017, given that Brent prices in 2018 to date have been some 30% above the 2017 levels.[113]

Figure 15: Chinese LNG imports and pricing, 1H18



Source: BP Statistical Review of World Energy 2018, World Gas Intelligence

Pipeline import volumes, while cheaper, have become unreliable

Over the period from 2013 to 2017 pipeline imports rose by 56% to 38 bcm/year[114] as contracted volumes from Turkmenistan increased and as volumes from Myanmar also effectively came on stream in 2014. In late 2017 supplies from Turkmenistan fell sharply as winter arrived, which

[113] www.statista.com https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/
[114] World Gas Intelligence 31 January 2018

exacerbated the problem of gas shortages in China caused by its rising demand. Various explanations have been advanced for the supply cuts, including the need for Turkmenistan to conserve gas for its own population, an attempt to improve its negotiating position with China and its broader economic crisis, but it is hard to be sure of the real reason and therefore how likely it is to recur.

Whatever the reason behind the shortfall, it prevented the former from taking full advantage of China's rising gas demand, which was instead met by increased LNG imports, seen as offering more flexibility as well as being cheaper in the spot market because of the then-oversupplied LNG market. As a result, overall pipeline volumes rose by only 13% in 2017, compared with the 45% growth seen in LNG volumes. Similar declines in 4Q deliveries have been seen every year from 2014 to 2017 as Turkmenistan diverts export gas to the domestic market when temperatures fall.

Turkmen gas imports (whose cost averaged $5.10/mmBtu in 2016)[115] are also more expensive than other Central Asian gas volumes, in part because of transit costs paid to Uzbekistan and Kazakhstan. Myanmar volumes, at $9.35/mmBtu in 2016,[116] are typically the most expensive pipeline volumes arriving in China since they come from the offshore Shwe field through a dedicated pipeline to Sichuan province in China. In the past, price appears to have come second to security of supply and has been used by China to maintain good relations with neighbouring countries – Myanmar gas is currently costing between two and three times as much as Kazakh gas. China's global investment initiative, the Belt and Road Initiative, may help lower the cost of pipeline gas through improved relations with key suppliers. Lower pipeline gas prices would then give China more leverage over its LNG suppliers.

Infrastructure investment decisions remain uncertain

China has long focused on the completion of the stalled Line D of the Central Asia-China pipeline - with a maximum capacity of 30 bcm/year[117] - as part of a broader programme of infrastructure expansion. This includes a potential second Russia pipeline with capacity of 30 bcm/year[118] and an expansion in LNG import capacity to 95 bcm/year by 2020 and to as much as 136 bcm/year by 2030. The start of construction of Line D was postponed in March 2017,[119] although there are now reports[120] that the line's construction has restarted and will ultimately be completed in 2020. Other reports[121] suggest that Lines A and B may instead be expanded and even that China may be interested in building a pipeline link to the proposed Turkmenistan-Afghanistan-Pakistan-India pipeline.[122] The most sensible conclusion to draw from all of this is that there are many options but no firm decisions seem close.

Looking further ahead, Gazprom said in October 2018 that the Power of Siberia pipeline is 94% complete.[123] China and Russia are now expecting the first (northern) section of the pipeline from Russia to start operations in October 2019 with an initial capacity of 5 bcm/year.[124] Deliveries through the Power of Siberia pipeline will ultimately rise to 38 bcm/year, although this volume is unlikely to be achieved before 2025. The strong gas demand growth seen in 2017 also appears to have given some

[115] www.haiguan.info
[116] www.haiguan.info
[117] CNPC.com.cn website and as discussed by Michael Lelyveld on Radio Free Asia 25 June 2018
[118] The Commercial and Political Logic of the Altai Pipeline, James Henderson, OIES 5 December 2014; The Paper, cited in Natural Gas Daily 23 July 2018
[119] Reported in The Diplomat 21 March 2017
[120] Ministry of Energy and Water Resources of Tajikistan, cited in bne Intellinews 2 February 2018
[121] World Gas Intelligence 31 January 2018
[122] Reuters, cited in Natural Gas Daily 9 August 2018
[123] Gazprom CEO Alexei miller at the St Petersburg International Gas Forum, cited in Natural Gas Daily 4 October 2018 https://www.energy-reporters.com/consumption/siberia-pipeline-93-complete-gazprom/
[124] Xinhua, cited in Natural Gas Daily 10 July 2018

renewed impetus to discussions about a second pipeline from western Russia,[125] although it is unlikely that the volumes would be as large as Russia would like (Gazprom has been quoted as saying it expects to deliver 80-110 bcm/year to China by 2035)[126] since there is a perception of good LNG availability in future years and there has been considerable investment by China in LNG import infrastructure. If China could secure access to upstream gas reserves in Russia this would improve the likelihood of a Chinese pipeline deal with Russia.[127] With Central Asian volumes somewhat unpredictable because of Kazakh and Uzbek prioritization of their own domestic markets, LNG has been prioritized in China. However, faced with continued rising gas demand in the medium-term, China has suggested better terms for Kazakh gas purchases.

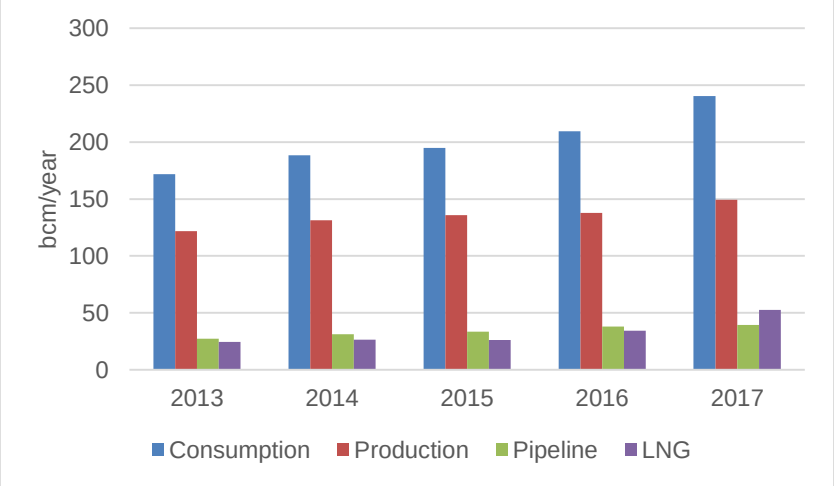
LNG imports have been rising – despite higher costs

LNG imports have also more than doubled over the period 2013-2017, although the rate of increase in 2016 and 2017 increased noticeably as additional receiving capacity was commissioned. Nevertheless import terminal utilization was less than 70% in 2017. Volumes rose by one-third in 2016 and by 45% in 2017 to 52.6 bcm[128] as LNG import growth eclipsed the growth in pipeline volumes. 2017 was the first year since 2012 that LNG volumes exceeded pipeline imports.[129] Partly this was due to lower spot LNG prices because of the surplus in the market and partly because increasing pipeline supplies at short notice is more difficult than acquiring additional spot LNG cargoes, which can also be delivered closer to areas of high demand when China's gas infrastructure in the north is at full utilization.

Qatar volumes were the most expensive among the major suppliers, costing $8.53/mmBtu in 2017, although not the most expensive overall. In 2017 that was LNG from Norway, although those volumes were small and are not shown in Figure 14. LNG is generally more expensive than most of China's pipeline volumes with the exception of the expensive gas from Myanmar.

LNG represented 54% of total Chinese gas imports in 2017 (Figure 16 below) and the proportion is expected to increase, with CNOOC forecasting that LNG imports will climb to 60% of China's total import volumes by 2020.[130]

Figure 16: China gas supply/demand balance, 2013–2017



Source: BP Statistical Review of World Energy 2018

[125] Nur Bekri National Energy Administration, cited in World Gas Intelligence 25 July 2018
[126] Gazprom CEO Alexei Miller, cited in World Gas Intelligence 11 July 2018
[127] Keun Woon Paik OIES, cited in Natural Gas Daily 14 March 2018
[128] BP Statistical Review of World Energy
[129] World Gas Intelligence 7 February 2018
[130] World Gas Intelligence 7 February 2018

2.5 Conclusions

From this analysis we conclude that, while China's domestic gas production has been growing, it is doing so at a slower rate than demand. Unsurprisingly, keeping gas prices low to encourage demand growth has indeed encouraged gas demand while disincentivizing supply growth – and this is likely to have a more significant impact going forward as the Chinese government moves away from controlling all prices towards a more liberalized market where the ability to subsidize the companies' gas production will be sharply curtailed.

Imports of natural gas continue to be loss-making for the NOCs, based on the evidence of PetroChina's 2017 and 1H18 financials, and the domestic price cut imposed on 1 September 2017 will only have worsened the position in 2018 – at least for gas volumes sold at regulated prices. Hence we have seen government pressure on pipeline tariffs – rate of return caps for example – as a way of reducing the cost of gas to end-users without creating a linked opposite effect on the gas producers themselves. (While the NOCs currently own the pipelines, more transparency is being mandated and the eventual aim is to create a national pipeline company based on NOC pipeline assets but separate from the NOCs).

Nevertheless, price reform in China's gas industry is increasingly necessary to encourage greater domestic production as well as aiding in stemming the losses incurred by the NOCs when selling imported gas in the domestic market. It will also help to retain gas' role in the future energy economy and avoid it being relegated to the minor leagues at an earlier stage than would otherwise be the case as the renewable energy sector takes an increasing market share.

3. China's gas price reform process

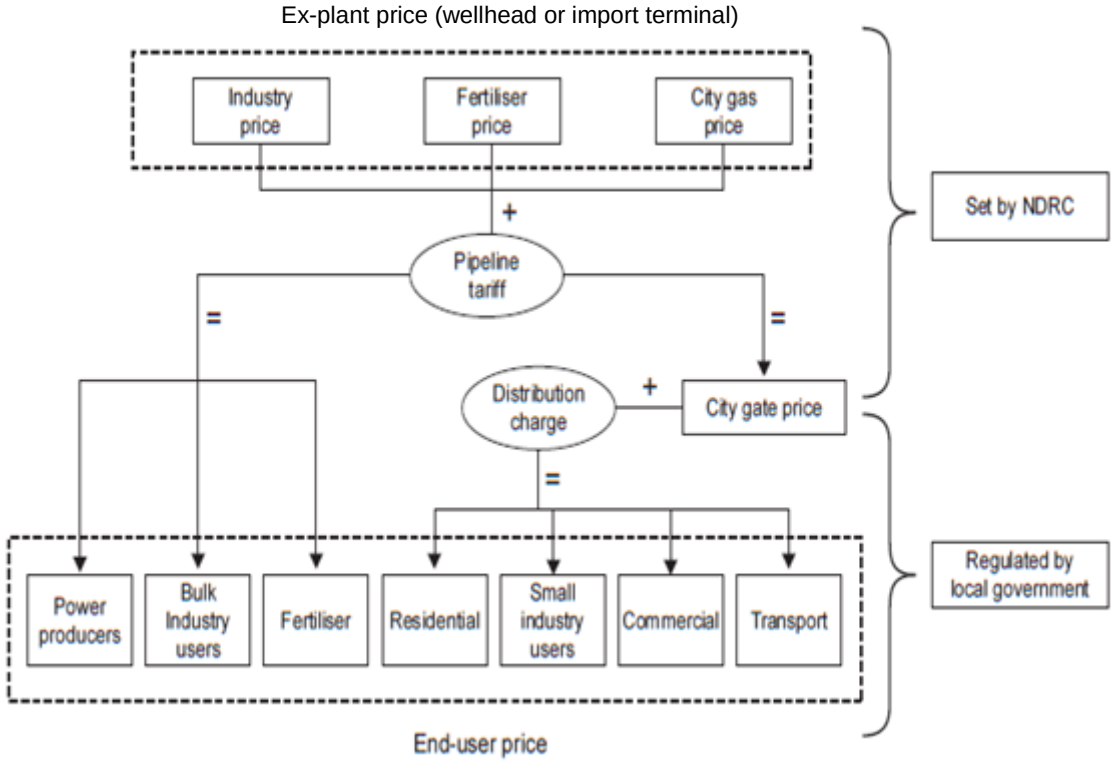
This section discusses the actual process of gas price reform in China, identifying the various stages through which it has passed – both for citygate (wholesale) prices and end-user prices. We assess the current situation in China in respect of residential prices (which have been heavily regulated but which the NDRC recently announced would be deregulated) and the development of seasonal gas pricing.

3.1 Early reform steps – modest price rises

The structure of China's natural gas pricing framework has been changing – and moving towards a more market-based framework – since 1982. Prior to that date, producers had to sell their gas to approved buyers, gas production was very limited, consumption was low and the price of gas was kept low to encourage at least some demand growth. This process of change has been unpredictable and spasmodic. Now in 2018, while it has not yet completed that journey, it is certainly more market-based than when the process began in 1982.

Until 1982 the gas industry was effectively centrally-planned, with output and prices both set by the government. In 1982, faced with declining gas production, the government increased the wellhead price and encouraged companies to produce more than their output quota through higher prices for additional volumes.

Figure 17: Pricing structure pre-price reform



Source: Chen (2014), Paltsev & Zhang (2015)

In 1993, pricing became a combination of a government-set price and a government-guided price as the Chinese economy was gradually liberalized.[131] The price of gas at the well-head and to the consumer varied considerably, depending on which field the gas came from. Prices were largely set by the various levels of government.

3.2 Mid-2000s reform – a simplified approach

In 2005 the NDRC started the next stage of the price reform process, with the ultimate aim of creating a more market-based price-setting mechanism. The main aims of these reforms were to:

- Streamline the number of wellhead prices to just two (Tier 1 and Tier 2) and consolidate the different types of consumer into a smaller number of groupings
- Create a link between the wellhead price and the price of competing fuels
- Increase overall gas prices and reduce the differential in wellhead pricing between the different grades of gas.

Even at this early stage, however, there were caveats and exceptions. The 'market-linked' pricing only applied to 15% of China's gas production (from Tier 2 fields), with the vast majority of gas production proposed to be priced on a market linked basis only by 2010, while there was a lengthy transition period – and annual limits - for most consumer price changes. Tier 2 prices were linked to the price of competing fuels though a basket of crude oil, LPG and coal prices, with an 8% annual limit on any price increase.[132] While the declared aim was that Tier 1 prices would steadily reach Tier 2 prices through an annual adjustment process over three years, in reality there was no annual price adjustment.

By 2008, China's average wellhead price was around one quarter of the average international gas price while prices to consumers were some 10-15% lower than the wellhead price, even excluding transport costs, while residential prices – usually lower than other prices – varied widely depending on the province.

In 2010 further minor reforms were undertaken. Production which had begun relatively recently (2006-2010) was exempted from the two-tier price system. Wellhead prices rose by RMB0.23/cm ($0.93/mmBtu) while producers and large consumers were allowed to negotiate prices around a benchmark price based on the wellhead price, which itself could vary by as much as 10% in either direction.

3.3 2011 – the move to netback pricing

These earlier reforms were a good start, but further reform was clearly necessary if the market was going to play a greater role in China's gas pricing. That did not take too much time to emerge – the next stage of reform began at the end of 2011. Pricing had become fragmented and uncoordinated across the country, investment in production and infrastructure was not being incentivized as the government wanted and China's gas supply portfolio was changing rapidly, bringing with it new pricing challenges.

The main elements of this reform were:

- The introduction of netback pricing – moving the pricing point from the wellhead to the citygate
- The establishment of a single citygate price ceiling for each province – applying to all onshore pipeline gas
- Trials of the new pricing methodology in Guangdong Province and the Guangxi Autonomous Region to inform a future planned nationwide rollout of the new system.

[131] Chen (2014)
[132] Chen (2014)

Shift from cost-plus to formula pricing

The first element was probably the most important. Prior to 2011 gas pricing had been constructed on the basis of a cost-plus methodology. This new reform up-ended that and instead established a market price set by a formula linking it to prices of oil products which competed against gas (LPG and fuel oil) with the aim of reducing the price differential between gas and other competing fuels. Shanghai was selected as the base point for pricing, with prices in other provinces calculated based on the Shanghai hub price with adjustments for differential pipeline transmission tariffs compared to the costs of gas delivered to Shanghai.

The pricing formula set out by the NDRC is:[133]

$P_{GAS} = K * ((\alpha * P_{FO} * H_{NG}/H_{FO}) + (\beta * P_{LPG} * H_{NG}/H_{LPG})) * (1+R)$

P_{GAS} is the tax inclusive citygate price in Shanghai in RMB/cm

K is a constant discount factor to encourage the use of gas

A and β are the weights of fuel oil (60%) and LPG (40%) in China's energy supply

P_{FO} and P_{LPG} are the average imported fuel oil and LPG prices in RMB/kg

H_{NG}, H_{FO} and H_{LPG} are the heating values of gas, fuel oil and LPG (8,000 Mcal/kg, 10,000 Mcal/kg & 12,000 Mcal/kg)

R is the VAT rate for natural gas.

The formula appears logical and comprehensive in terms of the influences of competing fuels on gas pricing in China. However, while the technicalities are not much at issue, the actual use of the formula is. The domestic gas price in China is still adjusted by the NDRC only infrequently and at relatively short notice. While, as we note later, analysis suggests that the prices set by the NDRC are in reasonable alignment with those likely to be calculated by the formula, the process remains opaque and unpredictable and we cannot conclude that the pricing formula alone sets a market price for gas in China.

3.4 2013 – two-tier pricing

The price reform process was taken further in 2013,[134] largely in response to the continuing strong demand growth – and the resulting financial losses by the major Chinese oil companies. The ostensible aim was to create a price adjustment mechanism that was both dynamic and reflected the fundamentals of both the gas and broader energy markets at a time when both the economy and energy demand were growing strongly. It also seems to have been aimed at eliminating inefficient industrial capacity which survived on the basis of lower than market energy price levels.[135]

Price adjustments are highly sensitive politically

Gas pricing, however, was a politically very sensitive topic which had to be handled carefully in order to preserve social stability - one of the government's key watchwords. There were also several different parties involved with contradicting vested interests. In order to minimize the societal risks of making price changes – which were invariably going to be upwards overall – the government decided to adopt a tiered pricing approach.

[133] National Development & Reform Commission 2011 & 2013 cited in Paltsev & Zhang 2015
[134] National Development & Reform Commission 2013
[135] Chen (2014)

The pricing of the majority of pipeline gas supplies to non-residential users continued to be set by the government as before. Residential prices also continued to be set directly by the government. The price of LNG supplies was already established by negotiations between Chinese buyers and the international gas sellers as was the price of unconventional gas such as shale production and coal bed methane, so the market already played the main role in these segments.

The majority (more than 90%) of gas supplies to non-residential users were termed 'base' volumes and these were defined as the actual volumes of gas which had been consumed in 2012. Volumes in 2013 and subsequent years in excess of those 2012 base volumes ('incremental' volumes) were to be priced on the basis of a formula shown in section 3.3, which established the value of gas based on the price of alternative fuels (in this case imported fuel oil and LPG) which could replace it.

Hence, the two most important changes in the 2013 stage of the price reform process were:

- The introduction of a two-tier pricing system for non-residential users, with the existing base (2012) volumes being priced at lower levels than the incremental volumes in excess of the 2012 totals
- The extension of the Guangdong and Guangxi trials of the new pricing approach to 29 of China's 33 provinces and municipalities, as envisaged in the 2011 reform.

In effect, this translated into a price increase to non-residential consumers in China. The longer-term aim of the first element was to move China conclusively towards market-pricing. While the price of the base volumes was still regulated, the steadily growing incremental volume share of non-residential gas consumption was priced by a netback linkage to international energy prices. The stated aim was that, by 2015, the two prices would converge towards the fully market-based price used for the incremental volumes and China would then effectively be pricing its gas at market prices.

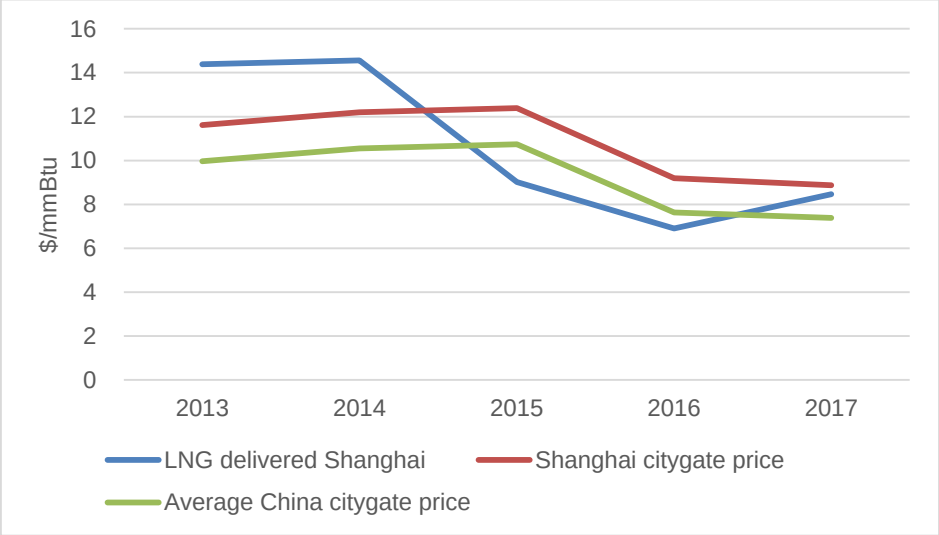
3.5 Recent implementation of the fundamental principles

The price reform process continued after the fundamental principles had been established in 2013. In July 2013, September 2014 and April 2015 directives from the NDRC set out price adjustments and the date on which they would become effective. There were further adjustments later in 2015 and in 2017.

Figure 18 illustrates domestic price movements over the past five years. It compares the average non-residential citygate price against the Shanghai citygate price and with the delivered cost of LNG imports into Shanghai.

The Shanghai citygate price and the average citygate price across China move in unison – the price differential between Shanghai and the Chinese average has barely changed in the last five years. With the fall in international oil and gas prices (represented by the delivered LNG line in the chart), domestic gas prices followed with a time lag. In 2013 and 2014 LNG imports into Shanghai were unprofitable at the gross margin level; 2015 and 2016 were better years while 2017 (and likely 2018 with the renewed oil price strength that is evident) showed a return to losses overall at the gross margin level. After distribution costs and lower citygate prices away from the pricing hub of Shanghai, as we noted earlier, imports of natural gas are a lossmaking activity for the Chinese oil companies.

Figure 18: Non-residential citygate price vs international gas price, 2013–2017



Source: CEIC, NDRC

July 2013

The first directive,[136] issued in 2013, raised the price of base gas by a small amount but set the price of incremental gas at a much higher level (on average 41% higher). This incentivized gas producers to increase output because the returns on meeting the incremental volume were much improved.

September 2014

There was a further average increase of 18% in the overall citygate price of RMB0.40/cm ($1.80/mmBtu) in September 2014.[137] The price of base volumes was increased while the price of incremental volumes was held stable, thereby narrowing the gap to 20% between the two and moving further towards a single gas price for China. Based on citygate price data across China we estimate the average citygate price was RMB2.57/cm ($11.69/mmBtu).

April 2015

However in 2015, with oil prices having fallen globally (Brent had fallen to $90/bbl) and demand growth slowing as a result of the continued impact of the 2013 and 2014 domestic price rises in a low energy price environment, the government changed direction on prices (but not on pricing policy). At the beginning of April the NDRC merged the two pricing tiers into one to create a single price for sales of gas to non-residential users across China.[138] The incremental gas price was significantly reduced by RMB0.44/cm, equivalent to $1.96/mmBtu because of the fall in international LPG and fuel oil prices while the base gas price was increased only slightly by RMB0.10/cm ($0.44/mmBtu) to reach equivalence with the international price-linked incremental gas price. The average blended price of gas across China was then estimated to be RMB2.51/cm or $11.26/mmBtu.

In addition, because of the way the pricing process works across China, cities and provinces furthest from the import locations in western China, pay higher pipeline transport costs. So the energy-intensive regions of Shanghai and Guangdong were paying even higher citygate prices - around $1.66/mmBtu more than the average price of $11.26/mmBtu and $4.60/mmBtu higher than China's westernmost province of Xinjiang where gas from Central Asia enters China with effectively zero domestic transport costs.

[136] National Development & Reform Commission 2013
[137] National Development & Reform Commission 2014
[138] Notice on rationalizing the price of non-residential natural gas, NDRC 2015

The NDRC did suggest to large-scale industrial users, apart from fertilizer producers, that they should negotiate prices directly with gas suppliers rather than follow the government-set prices. It also encouraged them to make use of the new oil and gas exchange established in Shanghai. Nevertheless, despite government encouragement of direct sales, progress has been slow, with access to infrastructure a particular concern, with the NOCs also claiming that city gas distributors and provincial pipeline operators have not opened up their networks to enable the NOCs and large users such as power generators to contract directly with each other. Provincial pipeline networks are nearly all controlled by local governments and Beijing's proposals would bypass the provincial networks.

In theory, from April 2015 onwards most natural gas prices should have been set by reference to international benchmarks. However, the price adjustment process remains opaque and the best that can be said is that international prices have an influence on the domestic gas price.

The timing and size of citygate price adjustments is unpredictable and subject to government policy and diktat, which can make it hard to plan investments and infrastructure. In addition, while the pricing formula used to establish the prices is transparent in its construction, detailed information about exactly how the price is calculated by the formula is not made available. Analysis carried out by Paltsev and Zhang in 2015[139] suggests that the NDRC-mandated citygate prices are in relatively close alignment with calculations made using reasonable estimates of the underlying variables. Nevertheless, it is hard to disagree with their conclusion that confidence in the government's pricing approach would be enhanced were more complete information about the underlying inputs and calculations made available.

At the time of the 2013 reforms the NDRC had envisaged adjusting the single gas price annually and eventually more frequently. With price changes having taken place in September 2014 and April 2015, expectations were for a further move before the end of the year with many observers suggesting that a 10-20% reduction would help restore the competitiveness of gas against competing fuels.

November 2015

A further price adjustment was made in November 2015 to reflect the new reality of lower international oil prices. Brent had fallen to $50/bbl and there were lower prices of LPG and fuel oil, against which gas prices were notionally being set. Citygate prices were cut by a flat RMB0.70/cm - a greater reduction than expected by the market – which was seen as likely to spur demand, albeit at the expense of producers' margins. The 28% reduction brought average prices down to RMB1.81/cm equivalent to $7.86/mmBtu. Once again Shanghai and Guangdong paid the highest prices (RMB0.37/cm, or $1.65/mmBtu, higher than the Chinese average) while Xinjiang paid RMB0.66/cm ($2.88/mmBtu) lower than the average. The average citygate price across China of RMB2.41/cm ($10.73/mmBtu) then actually moved above the cost of delivered LNG to China ($9/mmBtu) – creating a positive gross margin, a situation which persisted until 2017.

There were also some further adjustments to the pricing mechanism. The new citygate price in each area was now a benchmark rather than a ceiling, with buyers and sellers free to use that to negotiate around. Actual prices would be allowed to rise by no more than 20% while there would be no price floor. However the NDRC prohibited any price increases within a year, meaning not before November 2016 at the earliest. Speculation at the time centred on the potential for this change to encourage significant price reductions – although in reality it had the opposite effect because of the arrival of strong winter demand in late 2016.

The NDRC also again encouraged buyers and sellers to use the Shanghai Petroleum and Gas Exchange with the aim of reaching 'full market transparency' within two or three years. Volumes on the exchange had been modest until then but the exchange indicated it believed that it could manage additional volumes. However there remain structural impediments to spot trading of gas, particularly

[139] Natural Gas Pricing Reform in China: Getting Closer to a Market System", S Paltsev & D Zhang, Tsinghau-MIT

the control of the NOCs over the country's long-distance pipelines which means, for example, that most of PetroChina's pipeline supply is not freely tradeable.

Overall the consensus at the time among industry observers was that this price reduction would have a positive impact on demand. Other likely impacts were expected to be a greater desire on the part of China's NOCs – with expensive long-term gas import contracts – to renegotiate their contracts where they could and, if they could not, simply to resell their spare cargoes on the spot market.

September 2017

On 1 September 2017 the NDRC ordered a further price reduction for non-residential users of RMB0.10/cm, equivalent to a cut of $0.42/mmBtu or just over 5%. The NDRC[140] cited a combination of a reduction in the rate of VAT on natural gas[141] and a cut in the pipeline transmission cost for gas. It is likely that the aim of the price cut was to maintain the strong level of demand growth that had built up in the economy in 2016 and 2017, which supported the government's reform objective of reducing pollution through an increased use of natural gas. Coal consumption typically spikes in the winter period as coal-fired power stations are called upon to generate electricity and that adversely affects pollution. Lower gas prices are likely to encourage the use of more gas and less coal in industry and district heating.

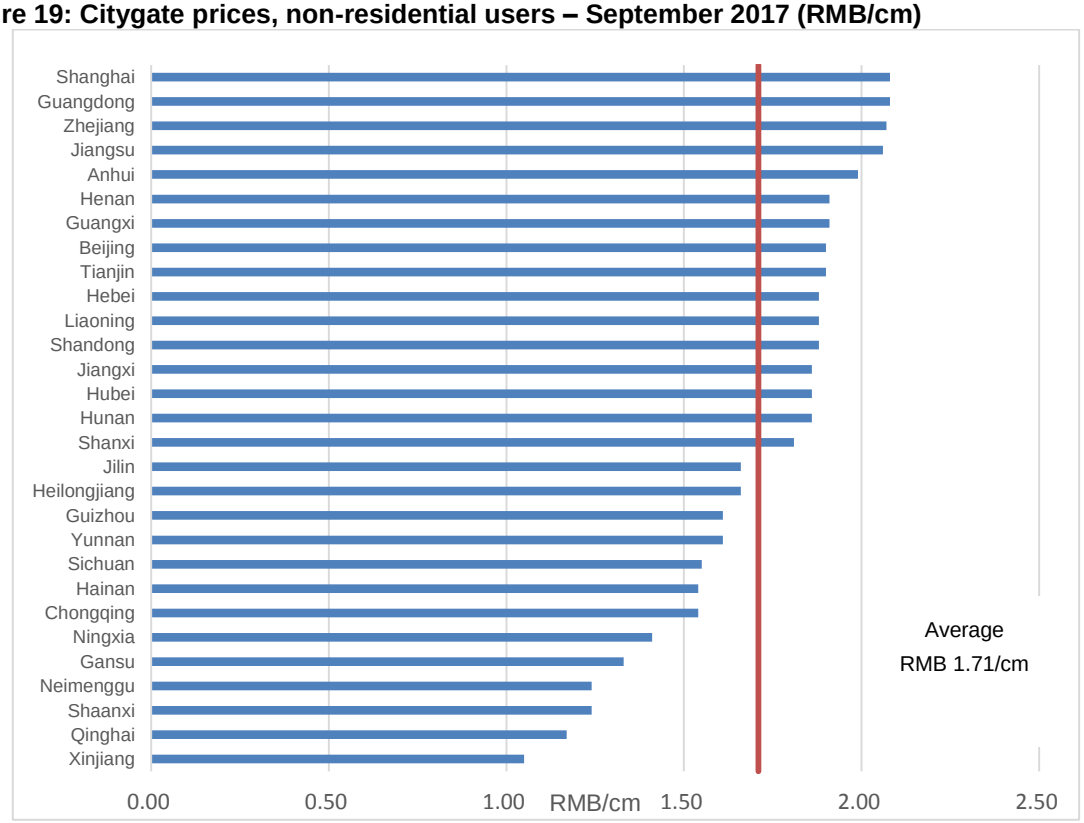
Opinions were mixed about the impact on the major oil companies and the gas distributors. In the case of the former the higher volumes which are likely to be sold by the NOCs could be offset by the lower prices that they achieve for those sales, although much of the price change was identified as resulting from changes in VAT and pipeline charges, of which only the latter impact the major oil companies. The gas distributors were likely to see increased sales volumes as a result of the lower prices and a continuation of the strong demand growth – subject as always to the speed at which the provincial pricing bureaux adjust end-user prices. The NDRC requested distributors to cut prices as soon as possible and officials in the Chinese gas industry suggested that it would take around a month for the cut to be completely passed through.

In addition to the gas price cut, the NDRC also reduced the fixed transmission tariff for trans-provincial gas pipelines by an average of 15%. This was the first time that trans-provincial pipeline tariffs had been cut since the government released a set of tariff regulations in 2016. The overall aim of the regulations was to break the stranglehold of the major oil companies on the national pipeline network. The NDRC also called on local governments to strengthen regulations on local pipeline transmission costs and cut local tariff and gas distribution fees by the end of 2018 as part of the reform process.

Figures 19 and 20 show the citygate prices for non-residential users by province, in RMB/cm and $/mmBtu terms. These are the NDRC-set prices which have been in force since September 2017. There is a wide variation in prices across the country, with the richer demand centres of Shanghai and Guangdong paying the highest prices while Xinjiang, in the west of the country, pays the lowest, partly because the cost of getting imported gas to the province is very low as the pipeline from Central Asia enters China in Xinjiang itself.

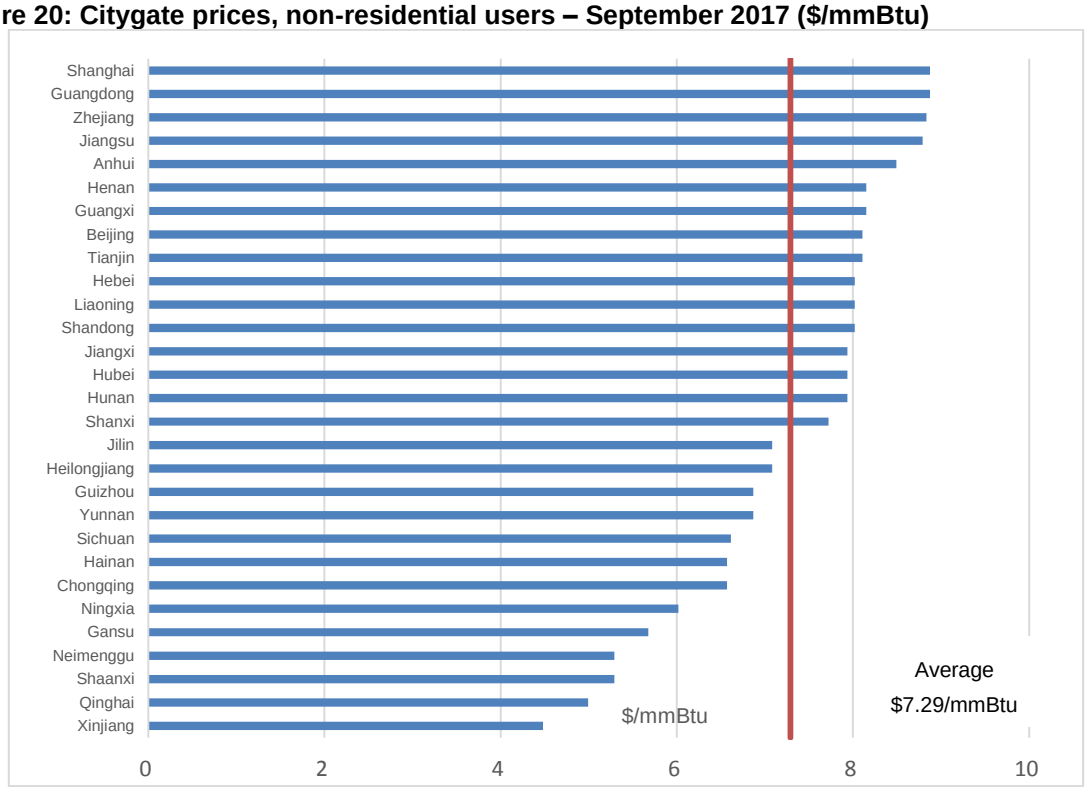
[140] Natural Gas Daily 30 August 2017
[141] Natural Gas Daily 21 April 2017

Figure 19: Citygate prices, non-residential users – September 2017 (RMB/cm)



Source: NDRC, ENN Energy

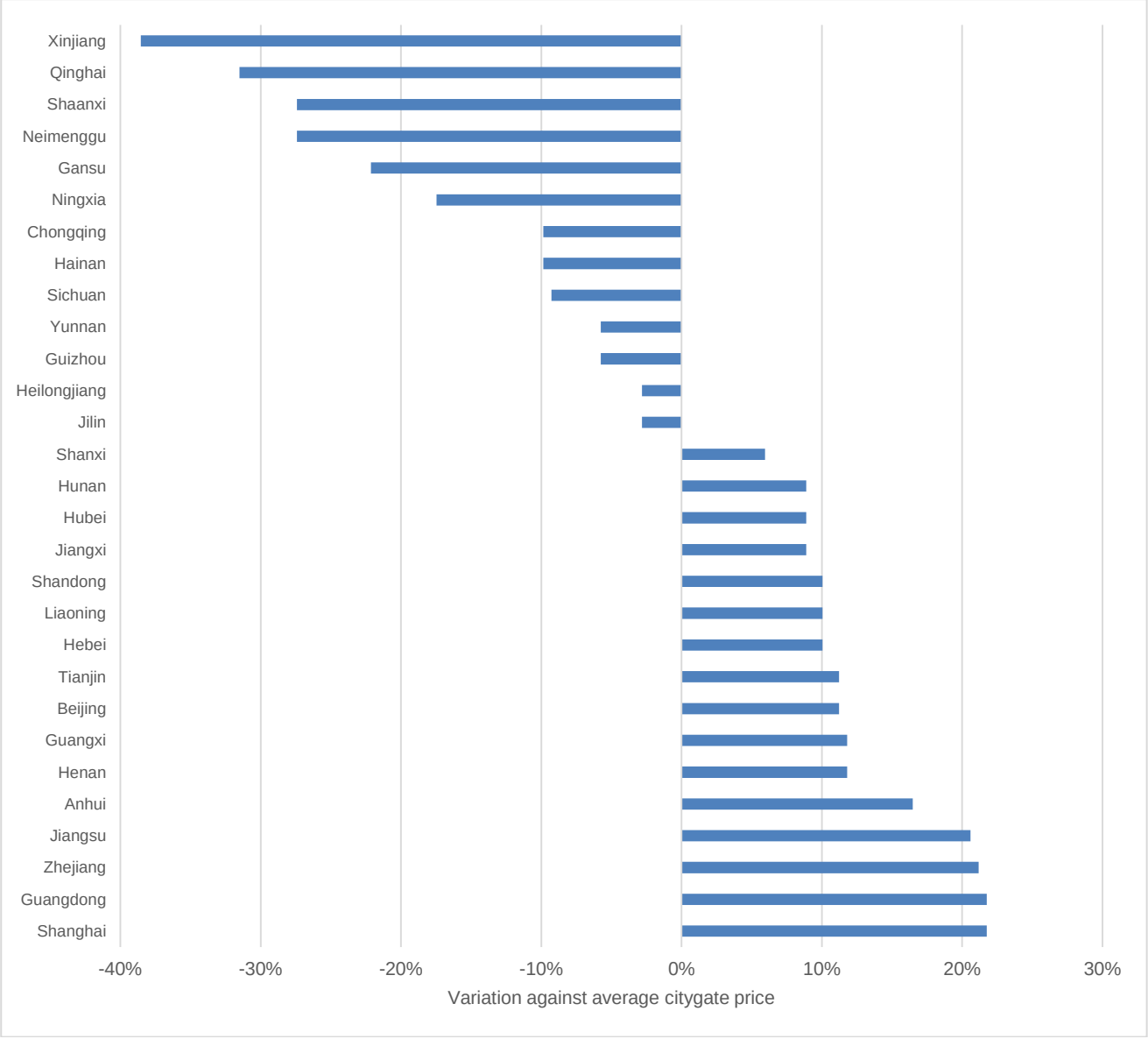
Figure 20: Citygate prices, non-residential users – September 2017 ($/mmBtu)



Source: NDRC, ENN Energy

Figure 21 illustrates the wide range of citygate prices in force across China, with prices in the demand centre of Shanghai on China's east coast twice as high as those in the far west province of Xinjiang, next to the entry point for Central Asian gas to China.

Figure 21: Citygate price variation – September 2017



Source: NDRC, ENN Energy

Each province of course has specific pricing issues. Guangdong, for example, is one of the provinces with the highest citygate price. The Guangdong branch of the NDRC is discussing with CNPC cutting the current citygate price of RMB2.08/cm to RMB2/cm as well as reducing the pipeline tariff by around 40% and cutting the local distribution fee by almost RMB1/cm – all with the aim of bringing down the price to end-users in Guangdong.

It may be hard for CNPC to simply cut the citygate price below the NDRC-established benchmark since this would undoubtedly encourage other provinces to ask for similar reductions. CNPC officials have suggested that reducing prices by cutting pipeline charges and local distribution fees would be an easier way to secure lower prices for consumers.

In early 2018, prices to residential consumers in Guangdong[142] were 35% higher than in markets such as Shanghai and Beijing, while industrial users paid 11% more and commercial customers 41% more. Guangdong is unusual, however, in that most gas in the province is supplied by CNOOC from its own offshore production and its long-term LNG contracts and is moved along dedicated pipelines owned by CNOOC. In addition, the company is not bound by the NDRC citygate prices and instead charges users based on what the gas actually costs it: in the case of North West Shelf LNG this is RMB1.45/cm to the residential and power generating sectors while in the case of all other LNG and offshore production it is RMB2.55/cm to the residential sector and RMB2.45-2.70/cm to the power sector.

Citygate prices can also be raised – as is the case with Inner Mongolia. Here, CNPC and the region's two distributors are in a legal dispute over the interpretation of a past contract where CNPC believes it is owed some RMB269 million[143] by the distributors. The dispute has gone to arbitration and the region has complained to Beijing. In the meantime, however, CNPC has told the distributors that supplies to them will be capped at the 2016 levels and they will have to pay a citygate price 10% higher than the NDRC-established level of RMB1.24/cm ($6.05/mmBtu) and a price 36% higher in the winter for peak-shaving gas. The arbitration ruling is still pending but it seems clear that citygate prices are not entirely set in stone.

June 2018

In May 2018 China announced that from 10 June it would unify the price of residential gas (which had hitherto been well below non-residential prices) with that of non-residential gas.[144] This was the first major change in China's residential gas pricing system for eight years and took both industry observers and the stock market by surprise.

Citygate tariffs for residential users, which had not changed since 2010, were freed from government control from June. Citygate prices for residential users were increased to the level of non-residential prices in June 2018 and since then the NOCs have been able to negotiate prices around that benchmark with the gas distributors – however prices cannot rise before June 2019. After that date, household prices will be allowed to rise to a level 2% above the non-residential price, although price cuts can be of any amount. In the next year the NDRC estimates that residential prices will increase by no more than RMB0.35/cm ($1.55/mmBtu), equivalent to a 24% increase in citygate prices. Not all cities were able to meet the deadline to revise prices – Hubei, for example, only started the process in early June[145] although Chongqing raised its residential tariff from 15 August.[146]

Residential prices in China have generally been heavily regulated because of the impact that sharp rises could have on the government's aim of maintaining social stability. The NDRC highlighted three reasons why these changes were being made:

- The average citygate price of RMB1.40/cm has been considerably below the cost of supply from imports and domestic production
- The current rigid tariffs cannot reflect changes in supply and demand, particularly when seasonal demand peaks in the winter
- With residential citygate tariffs being much lower than non-residential tariffs, city gas distributors have been arbitraging the system by requesting 'residential' volumes from the NOCs well in excess of actual residential demand; they then sell the excess to the higher-priced industrial sector which has led to disputes between the NOCs and the gas distributors.

[142] NDRC Guangdong branch, cited in Natural Gas Daily 19 March 2018
[143] Natural Gas Daily 9 May 2018
[144] Natural Gas Daily 25 May 2018
[145] Natural Gas Daily 30 May 2018
[146] Chongqing Pricing Bureau, cited in Natural Gas Daily 10 August 2018 http://www.cqpn.gov.cn/ndtxx/59240.htm

Overall we expect the impact on demand to be relatively limited. Residential demand is around 20% of China's total demand, there is already tiered pricing within the residential pricing framework so the largest users are already paying up to 50% more than the base price, and the estimated additional cost for a household resulting from these changes is just RMB7 ($1) per month while the NDRC has noted that it will subsidize consumers with below average incomes or living in northern China.

3.6 Changes to end-user prices

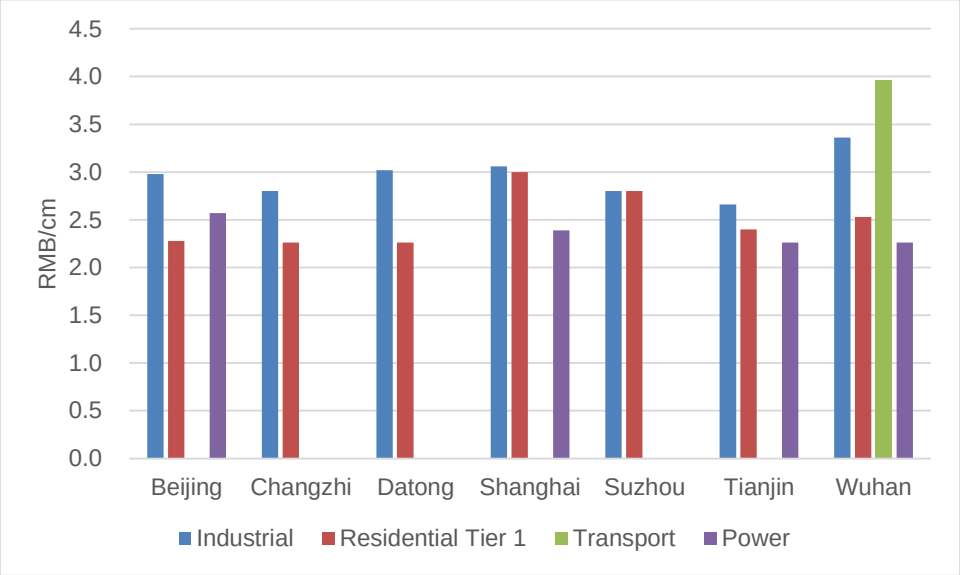
Consumers – whether residential, industrial or in other sectors – do not pay the citygate prices, which are regulated by the NDRC. Local gas distributors – such as ENN Energy, China Gas Holdings and Kunlun Energy – buy the gas at the citygate from the major oil companies, transmit it through their citywide pipeline networks and are allowed to charge a price by sector that delivers them a government approved rate of return. Some larger industrial customers negotiate directly with the gas suppliers (principally China's three major oil companies). Local pricing bureaux set the end-user prices across China.

Figures 22 and 23 show the end-user prices at the time of the last comprehensive revision to the citygate prices (September 2017) for seven cities where data is available across several sectors (residential prices, as noted earlier, have since been increased). This is a limited sample but there are a few conclusions that we can draw from this chart, including:

- Tier 1 residential prices are typically lower than industrial prices, or at worst equivalent to industrial prices
- Transport sector gas prices can be relatively high
- The price of gas into the power generation sector is usually cheaper than industrial sector prices and usually - but not always - cheaper than Tier 1 residential end-user prices.

The existing Tier 2 and 3 residential prices are not shown here to avoid an overly-cluttered chart but are discussed in Table 2 on page 51. Tier 2 residential prices (typically 10-15% higher than base residential prices and applicable to volumes in excess of 80% of the average monthly household volumes) can often be higher than industrial prices while Tier 3 residential prices (applicable to the largest residential users – those consuming in excess of 95% of the average monthly household volumes - and where prices are 50% above those of the base residential volumes) are invariably higher than industrial prices. The NDRC's recent announcement about the liberalization of residential prices made no reference to the tiered pricing currently in force but we assume that, with underlying residential prices rising, tiered pricing will be eliminated.

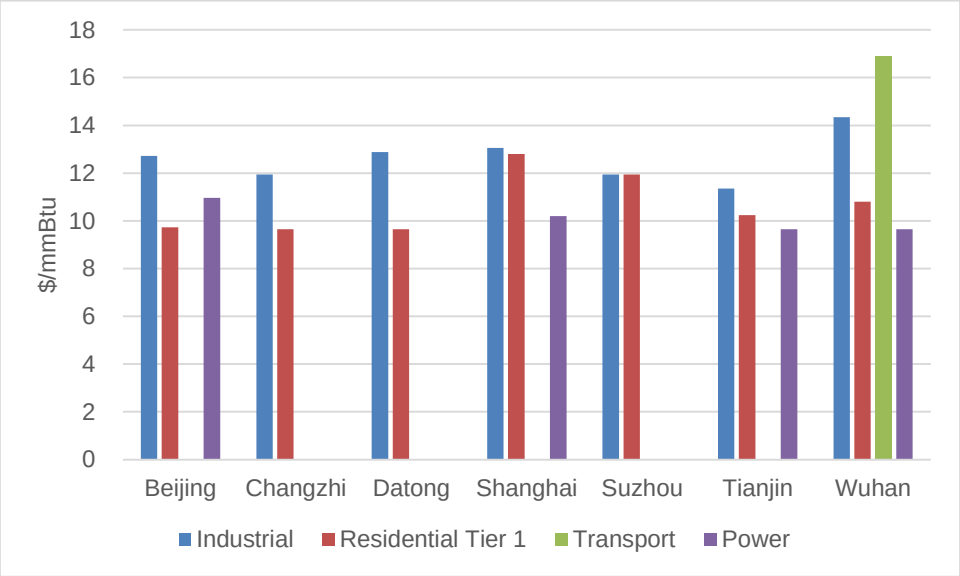
Figure 22: End-user prices – selected cities, 2017 (RMB/cm)



Source: Pricing bureaux

Note: Residential prices are tiered, Beijing and Shanghai also have tiered industrial prices

Figure 23: End-user prices, selected cities, 2017 ($/mmBtu)



Source: Pricing bureaux

Interestingly, in April Hunan province stopped regulating prices of gas used in taxis and buses, causing concerns about sharp price rises to transport companies.

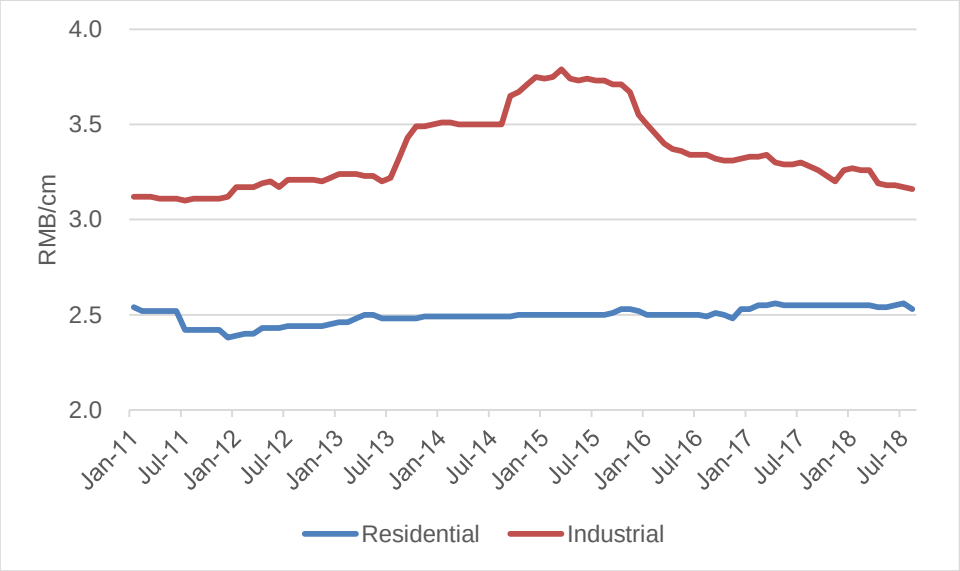
We now analyze two particular aspects of Chinese gas pricing in more detail:

- Residential prices
- Seasonal pricing.

3.7 Residential prices

Residential gas demand represents around 20% of total gas demand in China. NDRC data shows that natural gas is price competitive against alternative fuels such as electricity and LPG and in any case energy costs represent a relatively small share in household budgets (Hu & Dong[147] calculated it as typically less than 1% of disposable income in 2013. Residential prices have generally not been adjusted since then while per capita GDP has risen by almost 25%).[148] Nevertheless it is a particularly sensitive topic politically and only in mid-2018 have steps been announced to deregulate – and ultimately increase – residential prices. Structurally, this segment is growing, with government pressure for energy users – particularly in northern China – to switch from coal to gas for winter heating and a steadily expanding gas grid which has reportedly seen more than twenty million new households a year gain access to natural gas.

Figure 24: Regulated end-user gas prices, China average, 2011–2018



Source: NDRC, CEIC

There have been three key issues with residential gas prices in China:

- Residential gas prices in China have typically been lower than industrial prices – the reverse of the situation found in more mature gas markets. Figure 24 illustrates the price disparity over the past few years
- While the price to industrial end-users has varied with some degree of responsiveness to the international market, the base residential end-user price has been effectively flat for many years – although, as we note below, in recent years tiering has been introduced and in some cities the Tier 2 and 3 prices for gas to households (charged to larger consumers) is higher than the industrial price. As we note earlier, however, tiering is likely to be abolished now that residential prices are being deregulated.

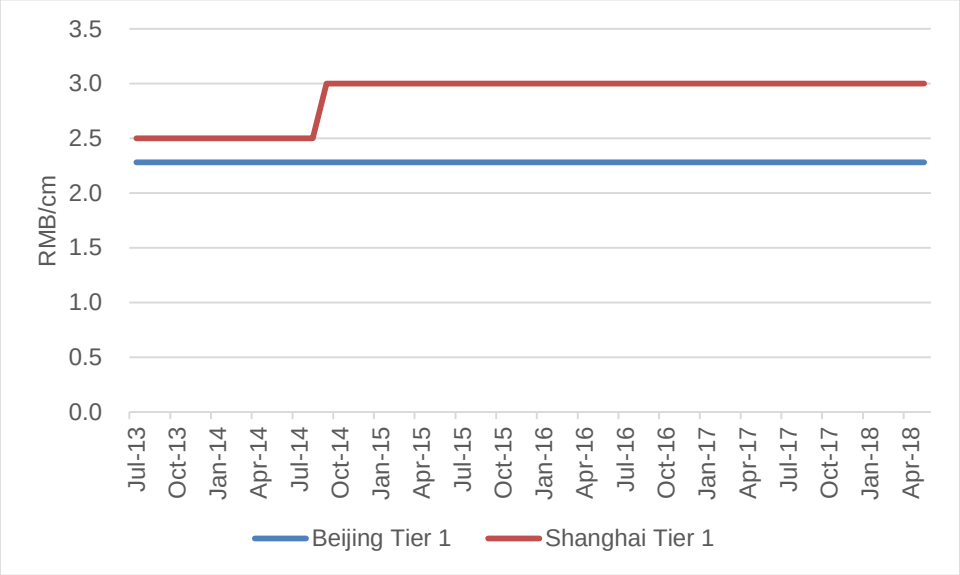
[147] Aolin Hu and Qing Dong "On Natural Gas Pricing Reform in China", cited in Natural Gas Industry B October 2015 https://www.sciencedirect.com/science/article/pii/S2352854015000716
[148] World Bank

- Finally, while tiered pricing has been in place in the residential sector and larger users are charged higher prices, the reverse is true in the industrial sector in large demand centres such as Shanghai – larger volumes attract a discount, which runs counter to the principle of stimulating gas demand without wasting scarce (and expensive) resources.

Relatively stable prices for many years

Residential end-user prices have been much more stable than industrial prices, as Figure 25 illustrates. Our analysis shows that in Beijing they did not change at all between 2013 and 2018. Shanghai prices have been similarly stable, although they are slightly higher in absolute terms than those in Beijing.

Figure 25: Residential sector end-user prices, 2013–2018



Source: National Bureau of Statistics

Until recently we would have said that it was reasonable to assume that in the medium-term this anomaly of low residential prices would be addressed, although with the Chinese government's focus on social stability, it was likely to be some considerable time before it was fully eliminated. The mid-year announcement of residential price deregulation caught most observers by surprise, despite past reports that the National Energy Administration had been working on plans to eliminate differential residential and non-residential prices. Residential prices have until now been subsidized from the profits made on industrial sales by the city gas distribution companies.

Now changing through tiering and deregulation

The deregulation of residential prices follows on from a series of moves in recent years. In 2014 the NDRC announced that tiering was to be introduced for residential prices by the end of 2015. Apart from having a restraining impact on gas demand in the residential sector, the changes tied in with Beijing's overall strategy of generally moving gas prices closer to the market. The move to a nationwide tiered pricing system for residential users also followed a pilot reform programme which was rolled out in Jiangsu in 2013.

The pricing system involved three tiers. The first tier covered those households which together made up 80% of residential demand. There was no price change for these households, meaning that gas bills for the majority of households in China remained unchanged. The second tier covers households using the next 15% of gas volumes while the third tier covers the last5 % of demand. Prices for the first tier, as noted above, remained unchanged when the system was established but prices for the second tier were typically increased by 20% and for the third tier (representing the largest residential

consumers) by 50%. Once the principle that those who use more should also pay more had been established (as it had been for water and electricity), further price adjustments to the residential pricing mechanism could be made. However, it was generally accepted that government involvement in the setting of residential prices would remain a feature of the residential market for longer than in the non-residential market because of the political sensitivity of the residential sector – hence the general surprise when the announcement was made that it was finally to be addressed.[149]

There had been some progress in closing the gap between residential and industrial prices over the previous few years. Hu & Dong in their research[150] note that, prior to 2005, residential prices were higher than, or equal to, industrial sector prices. That has long since changed and residential prices have been lower than industrial prices for many years. But the situation had been gradually changing – as Table1 illustrates. The last column shows the position post the June 2018 deregulation if prices were to rise by the maximum of RMB0.35/cm for the first year.

Table 1: Ratio of residential to industrial prices

Residential/Industrial	Sep-14	Sep-17	Jun-18
Beijing	62%	77%	79%
Shanghai	75%	98%	101%
Tianjin	65%	92%	93%

Source: NDRC, TS Lombard

In the last three years, the ratio of the residential price to the industrial sector price has improved (meaning that the residential price has increased relative to the industrial price) in the three cities where we have comparable data. Indeed in Shanghai the two prices are almost equivalent while even in Beijing – where the residential sector is of greater relative importance than in many other cities – prices have moved closer together (although Beijing still has the largest discrepancy among these three cities).

Ahead of the national rollout of tiered pricing by the end of 2015, a number of regions introduced tiered residential pricing in 2014 – including Yunnan, Guangdong, Guangxi, Henan, Heilongjiang and Liaoning. Sichuan – a gas producing hub in southwest China – introduced tiered pricing not just for gas but also for electricity and water.[151]

Table 2: Tiered pricing end-user comparison, September 2017

		Residential		Industrial
RMB/cm	**Tier 1**	**Tier 2**	**Tier 3**	
Beijing	2.28	2.50	3.90	2.98
Changzhi	2.26	2.71	3.39	2.80
Datong	2.26	2.71	3.40	3.02
Shanghai	3.00	3.30	4.20	3.06
Suzhou	2.80	3.08	3.82	2.80
Tianjin	2.40	2.88	3.60	2.66
Wuhan	2.53	2.78	3.54	3.36

Source: Pricing bureaux, Interfax NGD

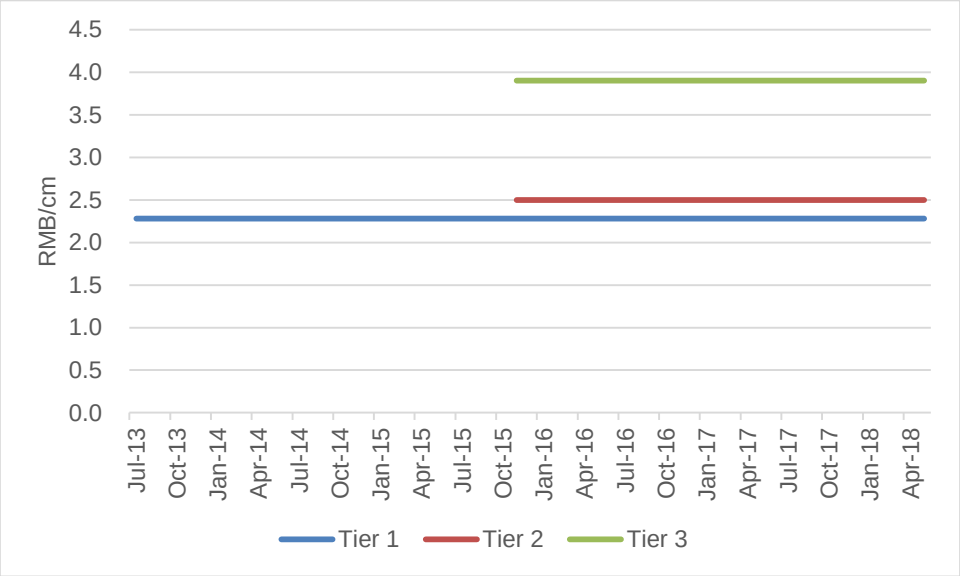
[149] National Development and Reform Commission, cited in Natural Gas Daily 25 May 2018 http://www.ndrc.gov.cn/zcfb/gfxwj/201805/t20180525_887218.html
[150] Hu Aolin & Dong Qing: On natural gas pricing reform in China 2015
[151] Natural Gas Daily 16 January 2014

Some residential pricing decisions being made at the local level

Individual cities were also able to make their own pricing decisions. For example, Lianyungang in Jiangsu province (where the initial trials had taken place) kept Tier 1 residential prices unchanged at RMB2.40/cm ($11.30/mmBtu) for consumption of up to 600 cm/year; raised Tier 2 prices by 10% (rather than the 20% in the government proposal) to RMB2.64/cm ($12.40/mmBtu) for volumes between 600 and 1,200 cm/year; and set Tier 3 prices (for consumption above 1,200 cm/year) at RMB2.88/cm ($13.60/mmBtu) which was a 20% increase on the Tier 1 price rather than the 50% increase set out in the government proposal.[152]

Beijing and Shanghai are two of the exceptions to the standard rule that Tier 2 prices are typically 20% higher than Tier 1 prices, while Tier 3 prices are 50% higher.

Figure 26: Beijing residential price tiering, 2013-2018



Source: National Bureau of Statistics

Beijing announced that it would introduce residential tiering in the city at the beginning of 2016.[153] In the capital the top 5% of households represented 15% of total residential gas consumption. Here again actual pricing levels and volumes were set at levels specific to Beijing. The first 350 cm/year of gas consumption was charged at RMB2.28/cm ($10.70/mmBtu); the next 150 cm/year was charged at RMB2.50/cm ($11.80/mmBtu); and volumes over 500 cm/year at RMB3.90/cm ($18.40/mmBtu). In Beijing, Tier 2 prices were set 10% above Tier 1 prices – as in Lianyungang – while prices for the top tier were set considerably higher at a 70% premium to the Tier 1 price. This high price for unusually large volumes of gas may simply reflect Beijing residents' greater ability to pay than those in other Chinese cities.

Shanghai's process (shown in Table 3) for arriving at its tiered residential price is instructive.[154] In mid-2014 the city proposed moving to tiered pricing from the previous system of a single price of RMB2.50/cm. The city finally settled on a compromise between two proposals.

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[152] Natural Gas Daily 16 January 2014 http://interfaxenergy.com/gasdaily/article/6111/china-preps-for-tiered-home-gas-pricing-rollout
[153] Natural Gas Daily 13 November 2015
[154] Natural Gas Daily 18 July 2014

Table 3: Shanghai price development process

RMB/cm	Tier 1	Tier 2	Tier 3
Pre mid-2014	2.50	n/a	n/a
Mid-2014 first proposal	3.02	3.62	4.53
Mid-2014 second proposal	2.50	3.32	4.23
Final outcome	3.00	3.30	4.20

Source: TS Lombard

The Shanghai price proposals were set at levels above those of Beijing. The proposals, when publicized, caused a swift popular reaction from many households sensitive to fluctuations in utility costs. Many were convinced that their views were irrelevant and that the increases were set to be imposed – indications of just how sensitive a subject residential gas prices are.

3.8 Seasonal pricing

Reflecting the fact that the government's move to create a more flexible and responsive market-linked pricing system has been having at least some effect, China's gas market has seen at least two examples of seasonal pricing within the last two years and may see a similar situation in the 2018/2019 winter.

Commercial decisions the driver, not government policy

While there were no government-mandated price changes in 2016, in November PetroChina and CNOOC both temporarily increased non-residential prices above the benchmark citygate price due to cold winter weather in China.[155] The NDRC had said that it would allow gas suppliers to raise the wholesale gas price by a maximum of 20% after the 2015-set prices had been in force for a year.[156] That period expired on 20 November 2016 and prices rose that very day. PetroChina's northern branch raised prices in its region (which includes the major cities of Beijing and Tianjin) by 15% from 20 November 2016 until 15 March 2017. PetroChina's northeast pipeline subsidiary announced that it would also raise prices by 10% during the same period. CNOOC's Tianjin LNG terminal announced that it had increased its pipeline gas and LNG prices by a similar amount. There was no immediate confirmation at the time that Sinopec had also raised its prices but the company did note that 'It is reasonable to increase prices in winter when supply is tight. This is permitted by Beijing'.[157]

PetroChina officials noted at the time that a price increase was necessary because of rising demand as district heating systems were switched on in response to a sudden plunge in temperatures[158]. The higher prices were aimed at dampening demand and encouraging supply. While additional underground storage facilities have also been proposed as solutions to the problem of a mismatch between supply and demand as winter arrives in northern China, PetroChina officials have suggested that the cost of filling UGS and then withdrawing gas was prohibitive[159] – apart from the fact that China's underground gas storage capacity is proportionately much lower than many other large gas consuming countries.

The government took no explicit role in the price negotiations, other than preventing any price rises before 20 November 2016. Nevertheless, the gas distributors on the other side of the negotiating table from PetroChina highlighted that it was an unequal negotiation simply because PetroChina is

[155] Natural Gas Daily 17 October 2016 and 22 November 2016
[156] NDRC, cited in Natural Gas Daily 22 November 2016 http://www.sdpc.gov.cn/zcfb/zcfbtz/201511/t20151118_758883.html
[157] Sinopec gas sales subsidiary, cited in Natural Gas Daily 22 November 2016
[158] CNPC statement, cited in Natural Gas Daily 22 November 2016
http://news.cnpc.com.cn/system/2016/11/15/001620703.shtml
[159] Xu Bo, PetroChina Senior Economist, cited in Natural Gas Daily 22 November 2016

the dominant supplier in the northern part of China and there was still only limited transparency on gas pricing.[160]

The speed of passing through price adjustments to consumers is always an issue

The key question for the distributors is always how quickly they are able to pass on the citygate price rises to their customers through changes in the end-user prices so that their margins are protected. Delay can be caused by the need to obtain approval from the local and regional pricing bureaux. In this case, the first non-government-mandated price rise, anecdotal evidence suggests that a number of cities did in fact approve a price increase for end-users relatively quickly.

Prices returned to the government-set levels at the end of the 2016/17 winter (15 March 2017)[161] as Figure 27 below illustrates.

2017 saw a similar situation. In November, PetroChina again raised the non-residential gas price by 10-15% reflecting strong demand and reduced supply in China.[162] The 2017 price rise was somewhat more complex than that of 2016. In late 2017, prices rose by 10% on 'base' volumes, with base being defined as the volumes consumed between April and September 2017. There was a 15% price rise on the same amount of gas as was used in winter 2016/17 (October 2016 to March 2017). If total volumes exceeded that level, distributors and bulk users had to use the Shanghai Petroleum and Natural Gas Exchange to buy the additional volumes to meet their needs. There was a price cap on the exchange of 20% above the regional benchmark and anecdotal evidence suggested that deals had generally been concluded at the level of that 20% price cap. Seasonal pricing ended on 15 March 2018 and prices were reduced at the end of the winter heating season to the NDRC-established citygate prices.

Seasonal pricing has actually been a reality for many years

Reviewing the prices charged to industrial consumers in the major markets of Shanghai and Beijing is instructive (Figure 27). While the NOCs' winter price increases in 2016 and 2017 were widely-reported in the media, the chart below tells two elements of a broader story. First of all, these were not unusual price moves, certainly for Shanghai. Every winter covered by our analysis has seen the same pattern of price increases in Shanghai, which are reversed after the end of winter. Beijing on the other hand has not seen the same pattern of annual price rises – prices have risen and fallen over a longer time horizon and have almost always been below those of Shanghai over the last six years.

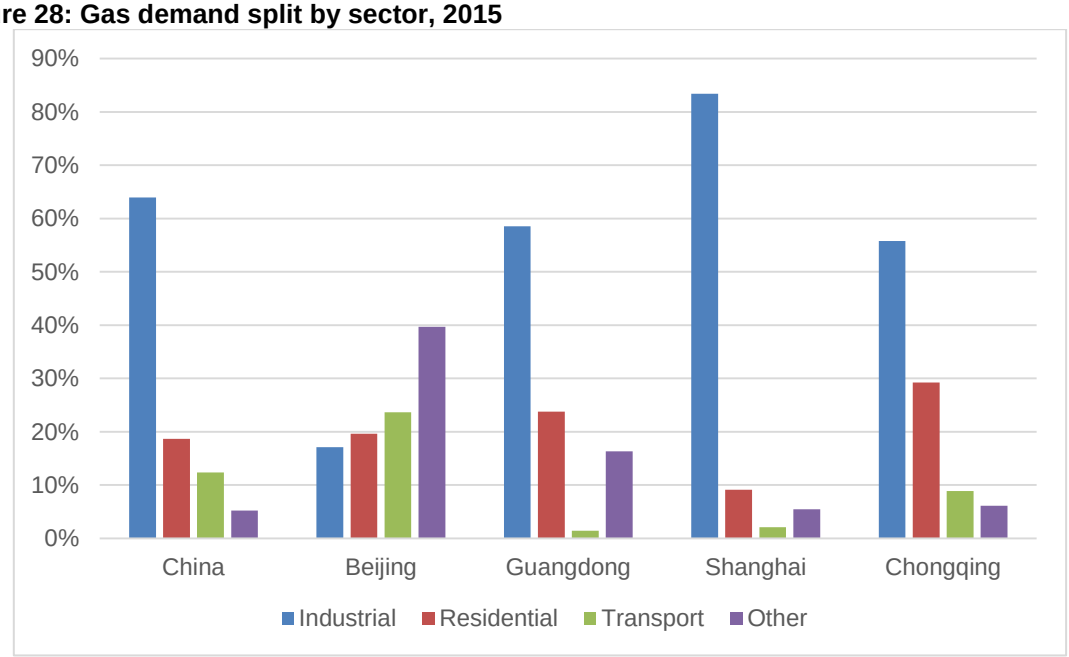
[160] ENN Energy Holdings executive, cited in Natural Gas Daily 22 November 2016
[161] Natural gas Daily 22 November 2016
[162] South China Morning Post 6 November 2017 https://www.scmp.com/business/companies/article/2118615/petrochinas-shares-fuelled-move-increase-natural-gas-prices

Figure 27: Industrial sector end-user prices, 2011–2018

Source: NDRC Price Reporting Centre, CEIC

Part of the reason may be explained by Figure 28. Beijing – apart from its obvious political importance as China's capital – has a higher demand for gas in the residential sector than in the industrial sector, in contrast to much of the rest of China. The reverse is true in Shanghai: industrial demand clearly dominates that city's demand profile. Hence the need for industrial sector gas prices to be more responsive to the demands of the market than in Beijing where residential prices are clearly more important. Similarly, gas in the industrial sector is the most important in Guangdong, the manufacturing hub of the Pearl River Delta and also in Sichuan.

Figure 28: Gas demand split by sector, 2015



Source: China Energy Statistical Yearbook 2015

A more analytically-based price adjustment in 2018/19

As we approach the winter of 2018/19, PetroChina looks to be preparing significant price rises as a way of forestalling gas shortages during that period. The company is currently renegotiating its contracts with its customers and has reportedly been asking for substantial price increases as a way of pricing marginal demand out of the market.[163] It has divided its non-residential customers into two groups – large industrial users which are supplied directly and city gas distributors which sell on to end-users in large cities.

Prices for directly supplied customers are to be increased by a standard 22.7% premium to the local citygate price.

Prices for city gas distributors are to be set through a new pricing formula:

- The first tier is called the base volume. PetroChina will supply the same volume of base gas as it did last year plus an additional 8%; these volumes will be charged at a premium of 20% over the regulated citygate price if they are sourced from domestic production or pipeline imports, if they come from gas sources whose pricing is deregulated – such as LNG imports, shale gas and coal bed methane - prices will be 27-40% above the citygate price
- The second tier includes all volumes above the base volume up to the peak of last winter's demand. Prices for this tier will be set either at market prices from the Shanghai Petroleum and Gas Exchange or at a premium of 37-40% over the citygate price, depending on the location of the demand
- The third and final tier (the 'excess volumes') will be priced completely at market rates.

Clearly these price rises are more significant than those imposed during the past two winters and reflect China's experience of last winter when severe shortages appeared and the gas used to meet as much of the increased demand as physically possible had to be bought on the spot market and sold at a loss.

City gas distributors face two challenges in this environment. The first is that there is currently no effective mechanism for the distributors to negotiate with their non-residential customers to pass on the higher costs from PetroChina and there is not a lot of time for such a process to be established[164] before the winter – and with it the higher prices - arrives. The second challenge is that the approval of the pricing bureaux in provinces and cities is required before the higher prices can be passed through to end-users and this could take time to obtain and may not be acceptable to the pricing bureaux since the government's aim is to lower energy costs to businesses rather than to raise them. Industry observers do, however, expect that a compromise will be reached and that PetroChina and the city gas distributors will share some of the costs (with the possibility that some local governments may offer subsidies) which will mean that the actual price rise to end-users will be smaller than might otherwise be the case. However, this outcome will not be as effective as the full price increase being passed through to end-users as a way of reducing marginal demand.

[163] Energy Observer, cited in Natural Gas Daily 13 August 2018
https://mp.weixin.qq.com/s?__biz=MjM5OTY4NjAwMQ==&mid=2650094350&idx=1&sn=fe94cb93de4333732f6db27f79066859&chksm=bf3621108841a8063a066c1741fb56c94cf73c3dac4be35e4b95d4da24e242d2fb80153d0291

[164] Liutong Zhang, WaterRock Energy Economics, cited in Natural Gas Daily 5 August 2018

3.9 Conclusions

Overall, we can conclude that over the period from 2005 to 2018, and with progress seemingly moving more quickly in the last five years, China's gas pricing policy has moved away from one set entirely by government to one influenced to a more or less significant degree by the market. The most recent announcement that residential prices were to be deregulated is the latest sign that progress continues – albeit on an unpredictable timescale.

4. How China's gas pricing policy influences demand

Conventional economic theory suggests that price is one of the key drivers for demand. With China's government focused on increasing the use of gas in the country as a major contributor to reducing pollution what has been the impact of China's gas pricing policy on demand over the past few years?

In this section we assess, where possible with the evidence, the impact that price changes have had – and are likely to have - on gas demand in China. We review the 2017 gas demand outturn, which was very strong, the 2018 data that is so far available – showing similarly strong demand growth – as well as the longer-term forecasts for gas demand growth. Finally, we identify which pricing developments to look out for in order to assess the likely future path of demand growth over the next few years.

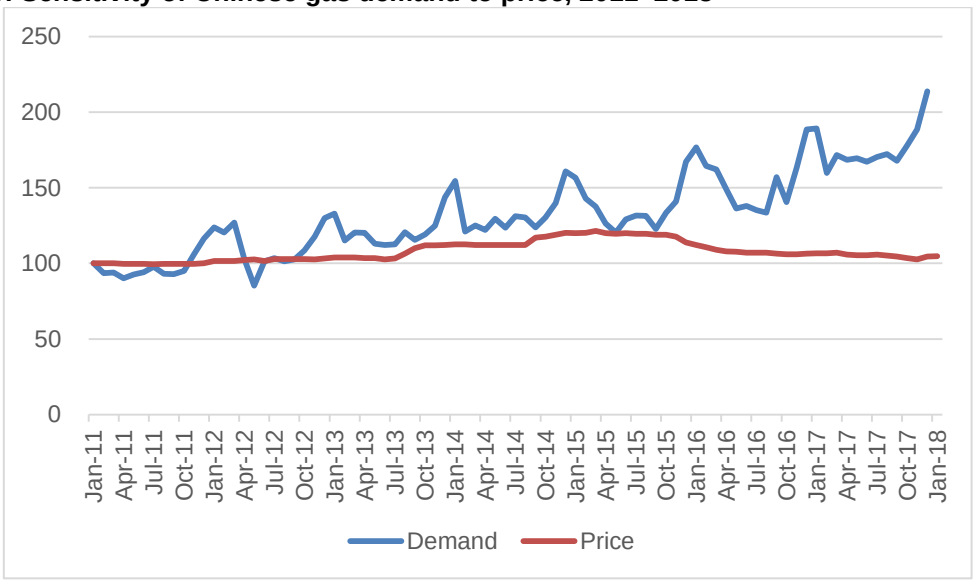
4.1 The impact of pricing on demand

As we note, one of the Chinese government's major objectives in the energy sector is to increase the use of gas to improve the country's environmental and air quality. Reducing the price of gas to increase its use across China has been one of the government's main levers, but not the only one, to achieve its policy objectives - whether the price reductions are achieved by regulating wholesale and end-user prices, reducing transmission and infrastructure costs or simply straightforward price control.

Has this worked? Have lower prices on their own stimulated gas demand in China? Looking at Figure 29 below, the evidence is mixed. In the chart we have shown total monthly Chinese gas demand (rebased to 100 in January 2011) since it has not been possible to identify monthly industrial demand on its own. This figure is plotted against the wholesale industrial price for gas. Residential prices (representing some 20% of total demand) have been relatively stable over the period, largely for political reasons, while end-user prices to the industrial sector have varied over time and can therefore be viewed as a proxy for 'gas prices' in China - as they are varied by the government to achieve its objectives.

Looking at the chart, there is no question that gas demand in China has risen steadily over the past seven years. The peaks and troughs of demand seasonality can also be clearly seen in the chart.

Figure 29: Sensitivity of Chinese gas demand to price, 2011–2018

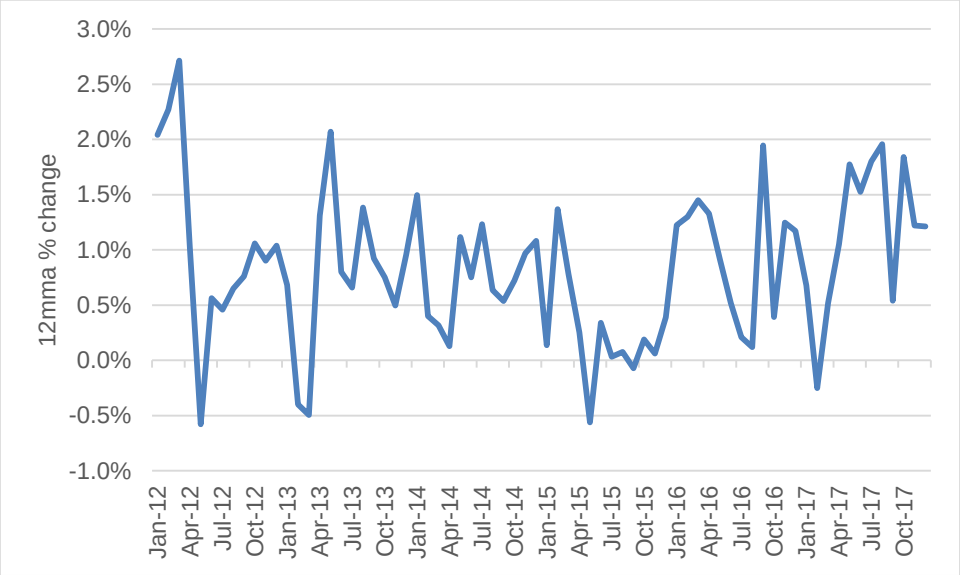


Source: NDRC, CEIC

The pricing effect on demand appears relatively limited

However it is hard to discern from this chart any clear pattern suggesting that prices alone have radically influenced demand. Figure 30 below shows the 12 month moving average of monthly demand changes. This gives a slightly clearer picture and suggests that after the large price increase in September 2014, there was a slowdown in the rate of growth into 2015. Growth only picked up quite sharply in late 2015. This could have been because of the 28% cut in the average price in November 2015 – although with the time lag for pricing bureau approval and the time lag that would be associated with fuel-switching, the effect is unlikely to be immediate, so most likely it was the normal seasonal pattern of gas demand as the winter heating season started.

Figure 30: 12 month demand change, 2012–2017



Source: Petroleum Argus

Non-price factors are more important

While economic theory and empirical evidence clearly suggest that rising prices should curtail demand while falling prices should stimulate it, there have also been other factors – both broader and more specific - at play in the Chinese gas market over this period. China's GDP growth rate has been declining, from above 14% in 2011 to around 7% in 2016 and 2017. That decline will have slowed the rate of growth of Chinese gas demand. Conversely, in 2017 and 2018 there was a concerted government-led policy to promote the use of gas rather than coal in the industrial and heating sectors in China. Most observers point to this as the most significant driver of gas demand over the past two years rather than the price reduction (which actually took place initially in late 2015).

Hence, while there is clearly an impact on gas demand from the prices charged – something acknowledged by the government when it focused on lower prices as a way of stimulating demand – it appears as if economic growth and, crucially, government policy are currently more important drivers of gas demand in China.

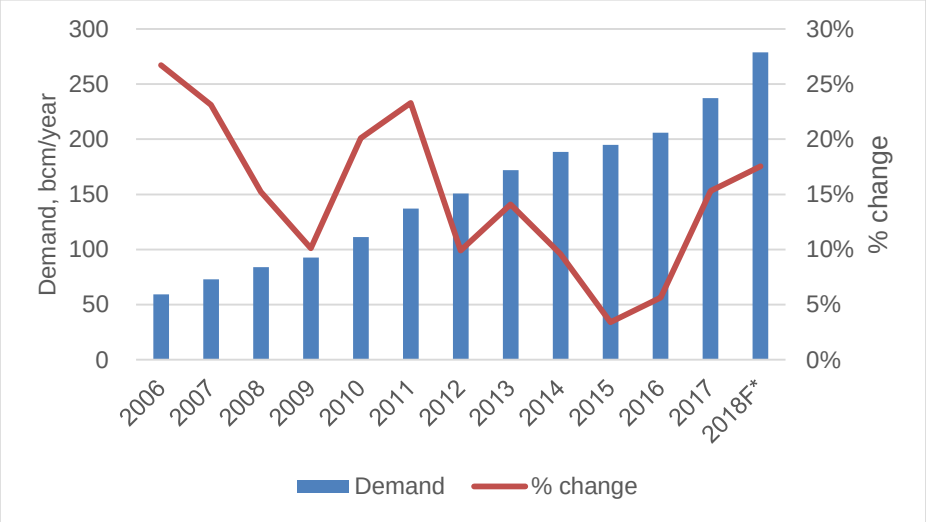
4.2 Recent Chinese gas demand growth

2017 outturn

Chinese gas demand increased by 15.3% in 2017, rising to 237.3 bcm,[165] with a particularly strong increase seen in the last few months of the year as the coal-to-gas switching programme ramped up (aided by the price cut in September 2017). The switching programme is estimated to have added 35 bcm/year of gas demand.[166] This strong 2017 growth compares with a 6% increase in demand in 2016. Overall Chinese energy demand grew by 2.9% in 2017,[167] implying that gas gained market share at the expense of coal and other fuels.

Domestic gas production rose in 2017 by just 8.2% to 148 bcm meaning that the supply deficit was met by increased imports, which rose by 27.6% to 92 bcm.

Figure 31: Gas demand growth, 2016-2018F



Source: BP Statistical Review of World Energy 2018, NDRC

*1H18 demand growth

2018 outlook

After the strong growth seen in in 2017, opinion started out divided on the 2018 outlook. Continued growth at the level seen in 2017 seemed unlikely to many. There is clearly still a drive to improve the environment through replacing coal with gas. However the 2017 push to increase gas use was thought to have relieved some of the pressure for radical action in 2018.

Demand growth in the first three months of 2018 did indeed remain strong, with the NDRC reporting an increase of 17.4% to 69 bcm against the same period in 2017.[168] The price cut in September 2017 will have had an impact as will the cold weather in the early part of 2018.

The second quarter turned out to be broadly similar. Demand in the first half of 2018 rose by 17.5% against the same period in 2017,[169] reaching 134.8 bcm and implying that demand in 2Q 2018 was 66 bcm. The NOCs had been forecasting growth of 12-14% in the first quarter and 14 % in the second quarter so an overall increase of 17.5% in the first half came as a positive surprise for the market.

[165] NDRC, cited in Natural Gas Daily 1 February 2018
[166] Guo Zonghua Shaanxi Gas Design Institute, cited in Natural Gas Daily 11 October 2018
[167] National Bureau of Statistics, cited in Natural Gas Daily 19 January 2018
[168] Natural Gas Daily 2 May 2018
[169] PetroChina Interim Report 2018

Consumption growth still well ahead of output growth

Chinese domestic output rose by 4.9% to 77.9 bcm in 1H18[170] while imports of gas through pipelines and as LNG totaled the equivalent of 58.4 bcm in the period[171] a 39.3% increase against the same period in 2017 (equivalent to import dependency of 43.3%). These rising levels of imports – albeit at high prices - continue to make up for the mismatch between the rate of growth in demand and the much smaller supply response.

Many demand forecasts for 2018 appear too low

Overall, the publicly-available consensus for 2018 still appears to centre on a 12% increase in Chinese gas demand to around 265 bcm after the 15% rise seen in 2017 – although this appears too low given the outturn in the first half. CNOOC is forecasting a 12% increase[172] while CNPC – China's largest gas company - is somewhat less optimistic, suggesting the annual increase will be just 10%, with demand rising to 259 bcm.[173] The company highlights a slowing of growth in the construction and chemicals sectors, only partially offset by good growth in the city gas sector, as being responsible for the slower-than-consensus growth that it forecasts. It did, however, highlight that the coal-to-gas conversion process will be more carefully-managed this year to avoid the gas shortages that have plagued China over the past winter. There have also been some broker forecasts with a similar, relatively downbeat, forecast.

Coal-to-gas switching is the key driver of demand

With government policy being a key driver of gas demand, the outlook for the coal-to-gas switching programme is an important determinant of demand. The government has also indicated that the intensity of the coal-to-gas switching programme is likely to be scaled back in 2018. The NEA has said in its annual plan that gas use should be promoted 'in an orderly manner'.[174] The Beijing-Tianjin-Hebei region, the Yangtze Delta, the Pearl River Delta and three northern provinces are the main targets of the programme in 2018 – in contrast to last year where the focus was exclusively on 28 cities in northern China. That said, many of the coal-to-gas switching projects completed in 2017 will only become operational and start to have an impact on gas demand this year.[175]

It will therefore impact 2018 demand growth, with the exact extent of the impact depending on how aggressively environmental policies are enforced and how affordable gas is for the key consuming sectors of power, industry and petrochemicals. However it seems as if the government has learned the lessons of 2017, where the over-ambitious implementation of the coal-to-gas switching programme led to widespread gas shortages in northern China towards the end of the year.

In addition, the government's 2018-2020 action plan, released in July 2018, banned the construction of any new gas-fired cogeneration capacity and chemical plants in the smoggiest parts of China – the Beijing/Tianjin/Hebei region. While that will undoubtedly slow the development of gas-fired power in China, it will also reduce pressure on winter gas supplies at a time when they are most in demand because of cold weather.[176] The region affected contains 58% of China's total gas-fired power capacity.[177]

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[170] PetroChina Interim Report 2018
[171] PetroChina Interim Report 2018
[172] Natural Gas Daily 25 April 2018
[173] Natural Gas Daily 17 January 2018
[174] National Energy Administration annual energy work plan, cited in Natural Gas Daily 12 March 2018 http://zfxxgk.nea.gov.cn/auto82/201803/t20180307_3125.htm
[175] Neil Beveridge, Bernstein Research, cited in Natural Gas Daily 15 January 2018
[176] State Council, cited in Natural Gas Daily 16 July 2018 http://www.gov.cn/zhengce/content/2018-07/03/content_5303158.htm
[177] Wood Mackenzie, cited in Natural Gas Daily 16 July 2018

Fuel switching is having a positive impact on both demand and the environment

Early-2018 environmental reports suggest that there was a 45-70% reduction in PM2.5 levels in the Beijing-Tianjin-Hebei region compared to one year ago, while there was a 20% increase in the Yangtze region's PM2.5 levels[178] and even a 4% increase around Hong Kong. The improved physical environment in areas where gas has replaced coal has encouraged continued pressure for coal-to-gas switching by the government in 2018 and, provided sufficient supplies and adequate infrastructure can be made available, we expect to see further strong growth in gas demand.

While many coal-to-gas conversions took place in 2017, a number of projects were held over because of unexpected shortages of gas and they will be joined this year by additional projects to continue the national programme. Government is continuing the pressure, even if keen to avoid the spectre of gas shortages that loomed over northern China last year. Coal users that have not yet completed the switch to gas will have to do so before the end of 2018. This could mean a substantial number of users making the change, with previous reports suggesting that in Hebei province alone, 50% of users have yet to make the switch. In January 2018 the local branch of the National Energy Agency in Hebei province, the epicentre of the coal to gas switching programme, after having said that it would slow or suspend the conversion process perhaps until 2019, said that it would in fact continue the process in the province – but would also work to secure a greater allocation of gas in 2018.[179] At the end of 2017, the central government ordered even more households in northern China to end their use of coal by 2021. By 2019 it wants cleaner fuels to supply 50% of northern China's heating requirements,[180] a figure which will rise to 70% by 2021. By then the government estimates that gas demand in northern China will have increased by 23 bcm/year as a result of these changes.

Economic growth is also an important driver of gas demand

Apart from these new environmental policies, the Chinese economy is expected to continue to grow relatively strongly in 2018 - at between 6-7%[181] - and this will also have a positive impact on gas demand.

Figure 32 shows CNPC's forecasts of gas demand growth in China across the main sectors.[182] While they are relatively conservative compared to some others in the market, they are helpful in understanding which sectors are predicted to show the strongest growth and where pricing could have the most impact. Looking at the three main sectors of residential, industrial and power generation demand, residential sector demand is forecast to more than treble over the period to 2050, with demand more than doubling in the first decade. With residential prices being liberalized from 2019, that change could act as a constraint on the predicted rate of growth in residential gas demand. Industrial demand – where prices are already deregulated but still government controlled in terms of the timing of price changes – is expected to rise by more than 50% by 2030. Given that industrial sector prices already vary over time, albeit at unpredictable intervals and by unpredictable amounts, these forecasts would seem to hold water. Power generation demand for gas is predicted to almost double over the next ten years, largely on the back of the government's medium-term efforts to improve the environment. Higher gas prices, if they are matched by higher electricity prices to end users, could constrain some of this demand, although government policy may also play a role in this sector.

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[178] Ministry of Environmental Protection, cited in Natural Gas Daily 13 February 2018 http://www.mee.gov.cn/

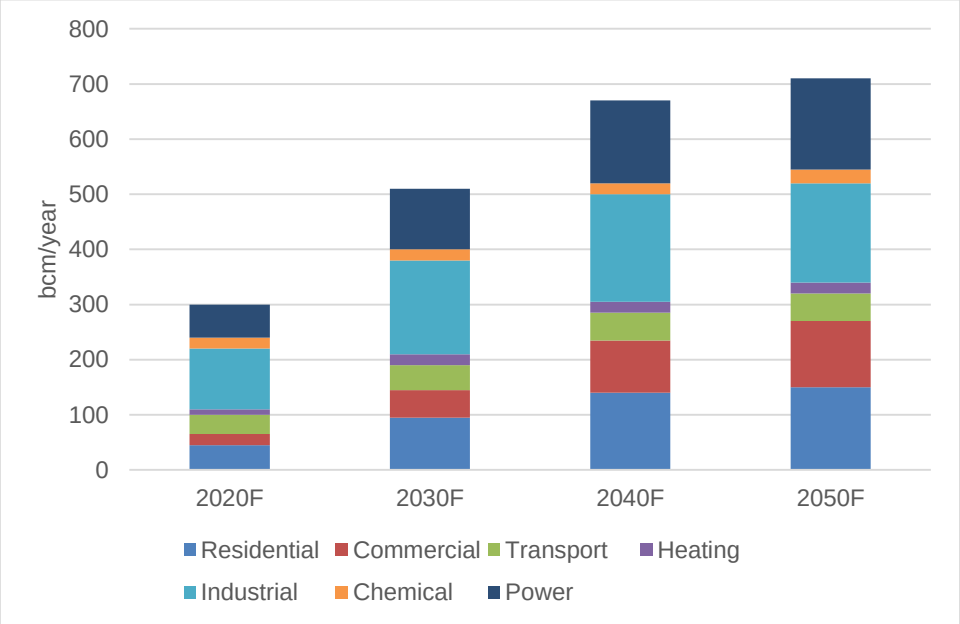
[179] Department of Energy Conservation and Equipment at the provincial branch of the National Energy Administration, cited in Natural Gas Daily 31 January 2018

[180] National Development and Reform Commission, National Energy Administration and others, cited in Natural Gas Daily 18 December 2017

[181] TS Lombard forecasts

[182] Natural Gas Daily 14 July 2016

Figure 32: Gas demand forecasts by sector, 2020F-2050F



Source: CNPC

Broader sector reform is still moving relatively slowly

The director of the National Development and Reform Commission said at the end of 2017 that he expected to see Beijing make progress on the establishment of a national oil and gas pipeline company in 2018, with the aim of opening up the market to third party suppliers, increasing competition, lowering prices and as a result increasing gas demand. This has been one of the objectives of government policy for some time but the NOCs oppose it since it is aimed at increasing competition and reducing prices to consumers – actions not necessarily in their interest.

There have been complaints that the major oil companies have been using their control of infrastructure to create gas shortages and maintain prices at higher than necessary levels. Industry observers have highlighted that the high prices caused by the shortages could adversely affect gas demand and stunt its growth, citing previous periods of high prices which then negatively affected gas demand in subsequent years.

While progress on the establishment of a national pipeline company has been slow, it clearly remains one of the government's objectives and has the NDRC lobbying for it. Creating a national company with open access to a wider range of gas suppliers is likely to improve overall gas supply in China, improve efficiency and potentially lead to lower costs to gas users – thereby encouraging demand growth, one of the government's key objectives. If third party access to pipelines is to be enforced, then ensuring similar access to LNG import terminals and local pipelines will also be necessary as, without those changes, gas imports will be unable to reach end users. CNOOC has started to allow third parties to access its Guangdong terminal so there does seem to be a willingness to consider new options to ensure that China's rising gas demand, and the government's policy objectives, can be met.

4.3 The longer-term outlook for Chinese gas demand

Chinese gas demand growth was generally on a downtrend in the years before 2017 despite the price changes that took place. The sharply positive outturn for 2017 was a surprise to many observers and, unsurprisingly, longer-term forecasts for China's gas demand were revised up over the course of the year. These are summarized in Table 4 on page 65.

Medium-term forecasts revised in 2017

At the beginning of 2017 the government (through the National Energy Administration) had a formal target that gas should represent 10% of total energy demand by 2020 and 15% by 2030. At the same time CNPC's forecast was that it would represent just 6.5% in 2017 and 8.9% by 2020, and highlighted that further reform in the gas sector was needed – such as the promotion of coal-to-gas switching through both subsidies and policy intervention, the deregulation of domestic gas prices and the completion of planned import terminal and pipeline capacity construction. In particular, presciently, it highlighted environmental protection as the key trigger for gas demand growth.

A few weeks into 2017, the NEA effectively revised down its forecast of 2020 demand to be a range instead of a point (8.3-10%).[183] CNPC continued to believe that the government's demand forecasts were too optimistic even with some reforms being undertaken. It argued that low gas prices were the key to achieving demand growth and that these could only be achieved through government subsidies. The government took issue with this, preferring to see the gas companies reduce their costs to deliver lower end-user prices – potentially through increased competition and a national pipeline company. However, as 2017 passed, little progress was made on either of these proposals because of opposition from the gas industry.

The first quarter 2017 actuals showed an increase of 9.6% against the same quarter in 2016, a figure which PetroChina described as 'far beyond expectations'. When the second quarter also showed very strong growth (overall demand in the first half of 2017 grew by 15.2%), PetroChina raised its long-term forecast for 2030 to 620 bcm – a sharp increase from its original forecast of 455 bcm. The China Energy Research Society (CERS) raised its 2020 forecast from 280 bcm to 290 bcm, while commercial industry consultants also raised their forecasts based on the first half's strong demand performance. The third quarter saw continued strong growth, with demand rising by 18.4% in the first 9 months of 2017. The fourth quarter was similarly strong as the coal-to-gas switching programme continued and overall gas demand rose by 15% in 2017.

The upgraded forecasts look more realistic these days

With the government focused on replacing coal with gas in both the power sector and industry, demand further out (to 2040) was also forecast to be higher than previously anticipated. Most of the growth is expected in the period to 2030, after which PetroChina expects the residential and industrial sectors to be saturated and demand growth to slow down from the predicted annual rate of 8% between now and 2030.

If China does manage to cap its carbon emissions by 2025 (as opposed to the COP21 target date of 2030) natural gas use could peak before 2040 – even though gas would be the one fossil fuel that would continue to receive strong policy backing from the government.[184]

CNPC disagrees with this downbeat assessment and expects demand to continue to grow and to peak at 695 bcm/year by 2050.[185] The company argues that Chinese gas demand is still in a rapid growth phase – the US market's rapid growth phase lasted thirty years, a period which saw demand rise almost fourfold. A combination of continued economic growth – even if at lower levels than in the past – as well as urbanization and the extension of the gas grid would make China the world's largest gas market by 2040.

[183] Natural Gas Daily 23 January 2017
[184] Zhou Dadi Vice-Chair China Energy Research Society, cited in Natural Gas Daily 5 January 2017
[185] CNPC Economics and Technology Research Institute, cited in Natural Gas Daily 19 September 2018

Government officials believe more gas sector reform needed to achieve such growth

Officials at the State Council's Development Research Centre agree with CNPC's mid-century forecast[186] but they also argue that further gas sector reform will be needed if such significant growth is to be achieved – including increased supply and even greater levels of coal-to-gas switching. If that proves to be the case, officials forecast demand at 700 bcm/year in 2050. Power generation demand is forecast by the State Council to be around 300 bcm/year by 2050, making it the largest single determinant of overall Chinese gas demand by 2050.

ENN Energy, one of the major independent gas distributors, believes that gas will succeed in reaching the target of supplying 10% of total energy consumption by 2020 after the strong 2017 demand growth and the outlook for the next few years. The coal-to-gas switching campaign is also set to be extended to southern cities as we have noted and, while this will not have the same impact as the campaign has had in the 28 northern cities – with their combined population of 200 million people - in which it is currently underway, it will still increase total gas demand in China.

Independents more concerned about impact of renewables

The independent gas companies have expressed growing concern about the longer-term impact of renewable energy on the demand for gas in China. ENN Energy which, apart from being a gas distributor, is also developing its renewables business, believes that renewables will cap gas demand by 2040 as the cost of generating electricity from solar power continues to fall.[187] The oil companies appear to accept the reality of this, with CNPC noting that renewables will be more cost-effective than gas with solar-generated electricity already competitive without subsidies, particularly for distributed generation projects which do not need to pay grid tariffs. However, this assumes that the problems of intermittency can be overcome and the cost of power storage in batteries can be significantly reduced.

Table 4: Selected Chinese gas demand forecasts

bcm/year		2017	2020	2030	2035	2040	2045	2050
NDRC	Actual	237		450				
NEA					650			750
State Council	Target		360	666			600	700
PetroChina	Initial			455				
PetroChina	Revised			620				
CNPC				520	620			695
CNOOC			340					
CERS	Initial		280					
CERS	Revised		290					
IEA	WEO 2017 New Policies			482	554	610		
US EIA	IEO 2017		249	412	492	582	689	792
Brokers			366	600				

Source: NDRC, NGD 5 January 2017, 17 August 2017, EIG, CNPC ETRI, broker research, IEA WEO 2017 Table 14.5 p590, EIA 2017, WGI 26 September 2018

[186] Guo Jiaofeng Development Research Centre, cited in Natural Gas Daily 5 January 2017
[187] ENN Energy Holdings, cited in Natural Gas Daily 5 January 2017

International forecasters expect strong medium-term growth

The International Energy Agency's most recent full World Energy Outlook (in 2017) forecasts that China will represent a quarter of all new gas demand between now and 2040, by which date it will have become the world's second-largest gas consumer, after the United States.[188] In its New Policies Scenario it forecasts Chinese demand to reach 610 bcm/year by 2040 – 11% of global demand - growing in the intervening period at an average annual rate of 4.6% compared to global gas demand growth of just 1.6%. The IEA identified power generation in China as the major driver of growth in global gas demand, adding 120 bcm/year to China's demand by 2040. Middle East power is the second largest driver while Chinese light industry is forecast to be the third-largest contributor to global gas demand growth. However, the IEA notes that achieving this growth will be harder than in the power generation sector because light industry is less concentrated in China and will require the construction of new infrastructure to connect up a wide range of smaller industrial facilities to the gas grid.

The IEA's latest Medium-Term Gas Report (in 2018) forecasts an 8% CAGR in Chinese gas demand between now and 2023, when it is forecast to reach 376 bcm/year, representing 37% of global growth in gas demand.[189]

With the IEA's forecast of slower production growth (even though it takes what appears to be an overly-optimistic assessment of China's unconventional output production potential), imports are expected to rise more sharply in China than in any other country.

The US Energy Information Administration also has more optimistic forecasts of Chinese demand - 582 bcm in 2040 and 792 bcm in 2050. Rising GDP, increased use of gas in power generation at the expense of coal, greater demand for gas in the residential and commercial sectors as well as increased use in the district heating segment are the major drivers of this forecast increase. The EIA takes an even more optimistic assessment of Chinese unconventional gas production than the IEA, forecasting 200 bcm/year in 2040 against the IEA's 100 bcm/year, meaning that any significant shortfall would imply an even more substantial call by China on world markets through increased imports.

4.4 What to look out for

Many of the short- and longer-term forecasts of gas demand in China imply significant growth in demand over a long period. Are they realistic and, crucially, what is needed for them to be achieved? Having some understanding of this will provide companies, governments and other interested parties with a guide as to what is likely to happen to Chinese gas demand over the near-term as well as the next twenty-five years. Government policy, economic growth and gas pricing will be the key demand drivers over the period. Certainly the Chinese government's medium-term target that gas should represent 15% of total energy consumption by 2030 leaves room for further growth, given that in developed gas markets, such as the EU, gas represents around 24% of total energy consumption while in the US it is 28%.[190] However, we should note that these gas markets matured at a time when renewable energy did not provide such a potentially interesting alternative to even relatively low-carbon fossil fuels such as gas.

[188] International Energy Agency World Energy Outlook 2017
[189] International Energy Agency Gas Market Report 2018
[190] BP Statistical Review of World Energy 2018

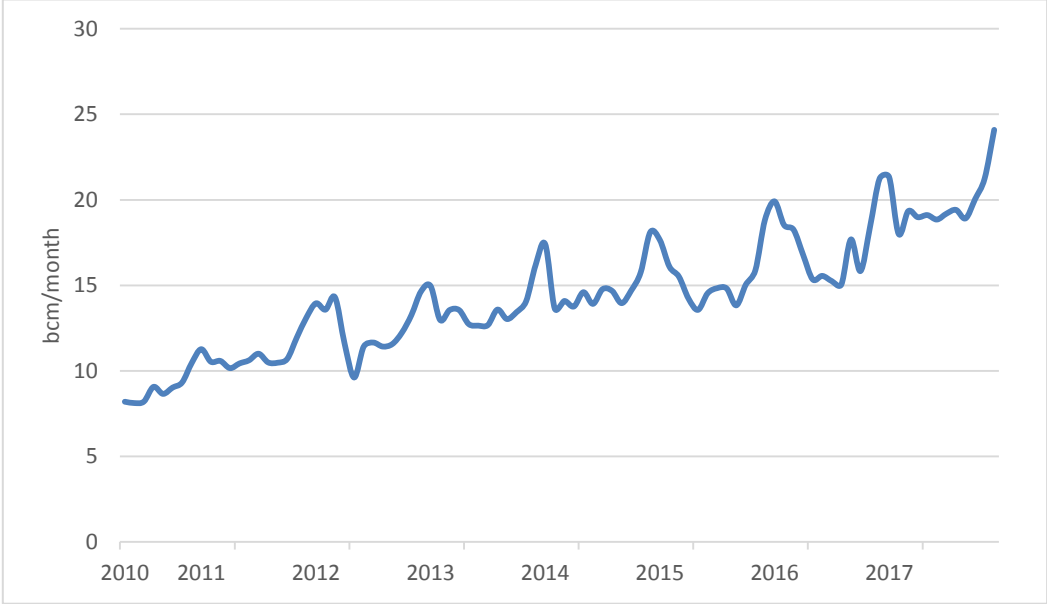
Key determinants of future Chinese gas demand growth include:

- Development and maintenance of a rational, market-led pricing system for natural gas in China, with appropriate incentives to stimulate demand in the various individual sectors, encourage domestic and imported supply and the rational allocation of resources across the entire sector
- Continuation of the current programme of coal-to-gas switching in the industrial and heating sectors – extending it to southern cities. The challenge here is that demand seasonality in northern China is likely to be much greater than in southern China because of the need for space heating in the northern winter (although a growing requirement for cooling in the southern summer will clearly have a seasonal impact on demand)
- Expansion of the programme into the power generating sector – with the challenge here being the installation cost of gas turbines and the higher costs for gas-fired generation (RMB2,500/mtce) compared with the cost of already-installed clean coal capacity (RMB1,000/mtce) which supports a large, nationwide coal-mining industry and may therefore gain political support as a result. That said, China's very large absolute demand increase may well enable gas to grow its volumes in the power generation sector at the same time as renewables, nuclear and clean coal
- Increased infrastructure investment – both private and government - to extend the gas grid and increase regional interconnectivity, build more storage capacity, increase the number of LNG import facilities and potentially construct new pipelines connecting China with gas-rich neighbours to diversify supplies
- Implementation of other aspects of reform – such as third party access to pipeline and import infrastructure, thereby enabling competitors to gain access to customers and reduce prices through the impact of increased competition
- Continued economic growth driving industrial activity and energy use
- Implementation of a carbon-pricing system to capture the externalities caused by the use of high-carbon fuels such as coal and oil
- The growing impact of renewables in the Chinese energy supply portfolio over the next few years.

4.5 Demand and price seasonality

As we highlighted earlier, gas prices are frequently seasonal in China (Figure 33), having increased in each of the last two winters and likely to do the same in the 2018/2019 winter; and energy demand – including gas – is also subject to considerable seasonality. As a result, one of the downsides of stimulating an increase in gas demand in China through pricing, coal-to-gas switching and the growth of gas-fired power generation is the difficulty of consistently meeting that demand and the consequences of failing to do so – particularly in a country like China which has strongly rising demand, as well as this significant degree of seasonality. Nowhere was this more evident than in northern China at the end of 2017, where provinces such as Hebei saw demand rise to as much as 230% of the previous year's level – and this with only 50% of users having fully converted by then from coal to gas.

Figure 33: China gas demand seasonality, 2010–2017



Source: Petroleum Argus

Seasonal price rises

Apart from causing serious gas shortages, the government policy of encouraging end-users to switch from burning coal to burning gas, has also led to seasonal price rises on the part of the major gas suppliers aimed at reducing excessive demand during the winter peak. Seasonal price increases occurred in the winters of 2016 and 2017 and have been one of the main tools deployed to manage the supply/demand balance in times of peak winter demand – which suggests two things. The first is that China's pricing mechanism is becoming more market-related and sophisticated. The second is that a longer-term solution would be to invest in additional gas storage capacity which would enable the country to more easily manage the winter demand peak without placing the burden of doing so primarily on the gas pricing mechanism.

This seasonality looks unlikely to go away. The switch from coal to gas in northern China, combined with the increased use of air conditioning in the south, means that seasonality of demand for gas has increased. This in turn has required imports of spot LNG cargoes to meet the demand in the absence of adequate storage capacity.

4.6 Conclusions

We conclude that the evidence that lower prices have significantly stimulated gas demand in China is mixed. There is undoubtedly some impact from lower gas prices but economic growth and government policies appear to have had more of an impact on gas demand. Hence policy effects are stronger than price effects. The strong growth seen in 2017 was largely the result of government policies supporting the promotion of gas – although there was a price cut in September. The outlook for 2018 is also looking quite strong, based on first half actuals and government policy remains supportive of the coal to gas switching programme. The longer-term outlook will be affected not just by the path of price reform but by government policy, economic growth, the advance of renewable penetration in China's energy and the overall gas sector reform process itself.

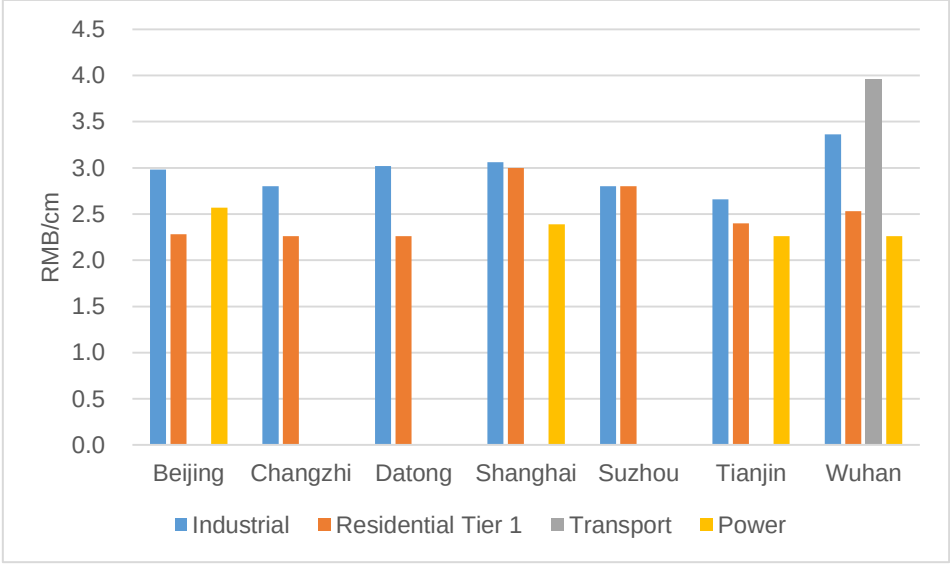
5. Regional price and demand variations

There are significant variations in gas pricing and gas demand across China. Each province is different and national-level observations can be difficult to apply to different regions. In this section we look at the price variations across China, attempt to identify the reasons behind these variations and discuss gas demand across China's provinces as well as the supply/demand balance for each of them.

5.1 Regional pricing variations

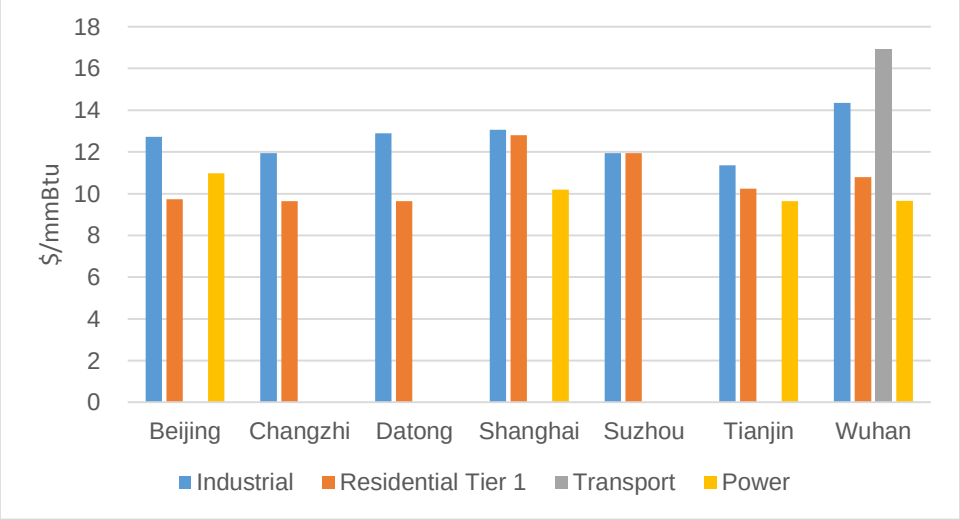
Figures 34 and 35 show the prices charged to end-users in the residential, industrial and commercial sectors across a range of provinces and municipalities in 2017 where data is available. The first is in local currency, the second in the more internationally-comparable $/mmBtu format.

Figure 34: End-user prices, selected cities, September 2017 (RMB/cm)



Source: Pricing bureaux

Figure 35: End-user prices, selected cities, September 2017 ($/mmBtu)



Source: Pricing bureaux

Note: Beijing and Shanghai also have tiered industrial prices

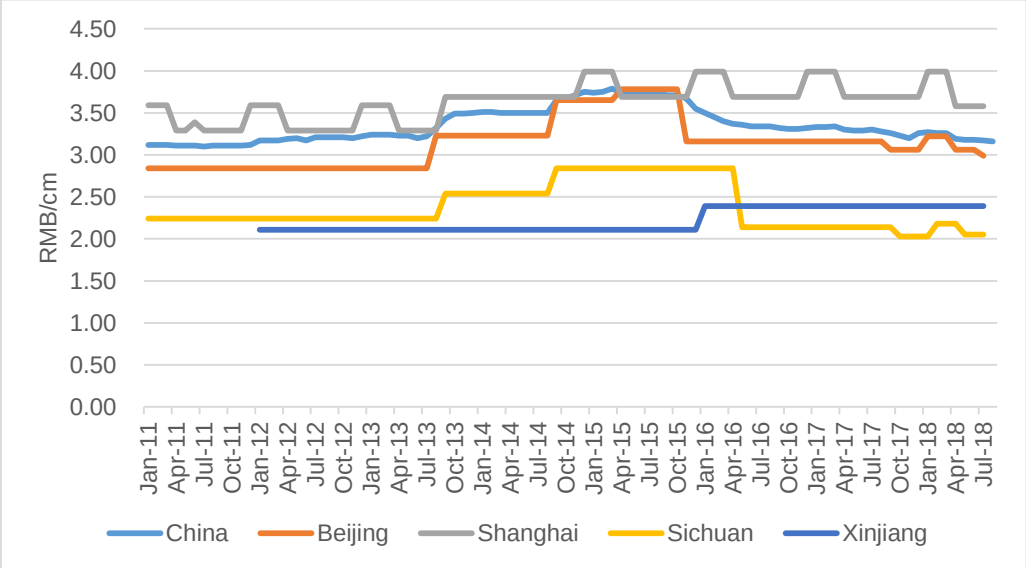
Several trends are evident:

- The first is that the Tier 1 residential end-user prices were generally lower than most other prices in each province
- In addition, some cities have tiered industrial sector prices offering volume discounts (for example, industrial prices in Shanghai are RMB3.86/cm for volumes below 1.2 million cm/year, RMB3.56/cm for volumes between 1.2–5 million cm/year and RMB3.06/cm for volumes above 5 million cm/year)[191]
- Finally, affordability is not the overriding factor, clearly politics plays a part. If affordability were the key criterion, consumers in Beijing would pay much higher prices than they currently do because the city is a long way from pipeline gas import points (although close to the Ordos Basin producing region). It is also exposed to LNG imports at international market prices and has the highest per capita GDP (and therefore the highest affordability) of any city in China.

There is noticeable variation in price levels and movements

We can observe the broader behaviour of the gas price charged to industrial users in a representative selection of markets in China, as in Figure 36. Based on data from the NDRC's Price Reporting Centre, over the last seven years industrial sector prices have generally moved in the same direction up or down – allowing for time lags of implementation (except for prices in the gas producing region of Xinjiang, where there has been just one movement). Over the period analyzed, Beijing and Shanghai have paid among the highest prices – reflecting the cost of delivering pipeline gas to those markets, the availability of market-priced supplies of LNG from the international market and the greater affordability of gas (and other forms of energy) in those markets. Xinjiang, as we noted, has had a particularly unresponsive pricing framework, perhaps due to the specific political circumstances – and the government response - in that province. The gas producing region of Sichuan has been as responsive to price changes as Beijing and Shanghai have been but prices have always been at lower levels than the richer (and more distant) cities of Beijing and Shanghai.

Figure 36: Gas price to industry, selected markets, 2011–2018



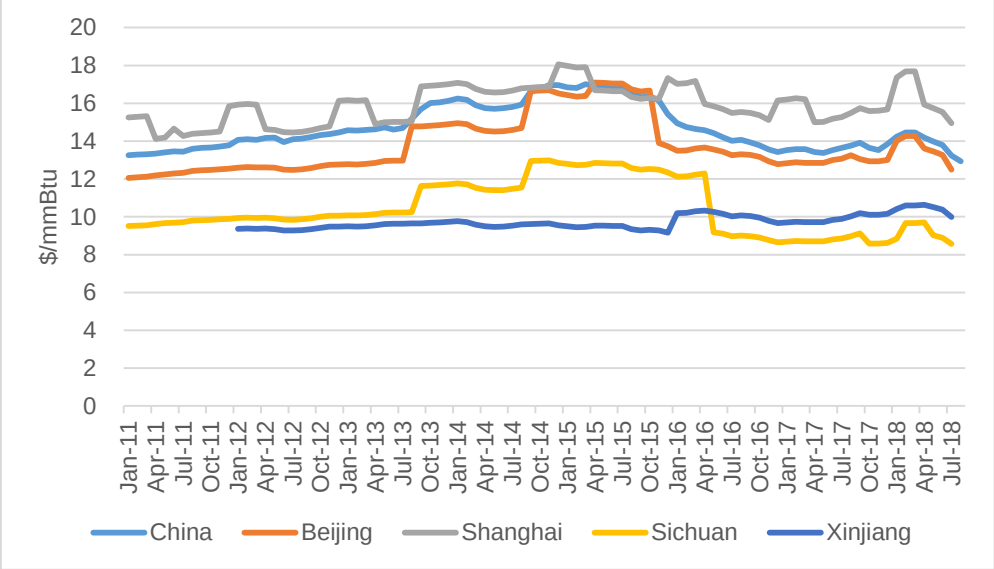
Source: NDRC Price Reporting Centre, CEIC

[191] Shanghai pricing bureau

To put these prices in a broader context, Figure 37 below shows the prices in $/mmBtu. The average LNG delivery cost to China in 2017 was $7.37/mmBtu[192] so including regasification costs of perhaps $0.40/mmBtu, delivery virtually to the Shanghai city gate would have been less than $8/mmBtu while the price to industrial end-users in the city was almost double that at $15.60/mmBtu in 2017.[193]

Shanghai is a uniquely high-priced market which has also been exposed to imports of spot LNG, often at low prices because of an oversupplied market. We should also note that the prices shown are industrial prices and gas sales to the residential and power sectors take place at lower prices. Out of the final price of course needs to be paid not just the acquisition cost of the LNG but also pipeline transmission costs (costs and an approved margin) and various taxes. More distant provinces typically have lower achieved prices and higher transmission charges. As we noted earlier in the report (page 23), PetroChina's gas import business makes a loss. While the 2017 loss was lower than was incurred in some previous years, the first half of 2018 has shown higher losses than the same period in 2017.

Figure 37: Gas price to industry, selected markets, 2011–2018



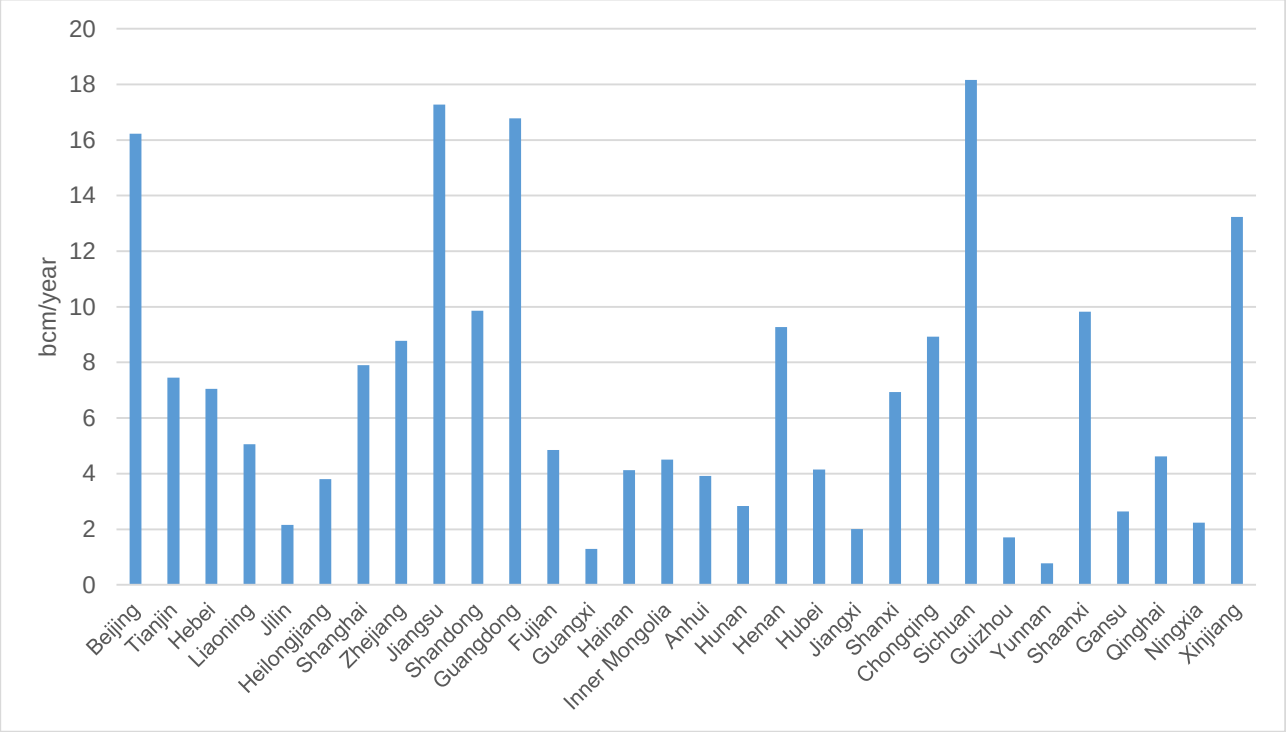
Source: NDRC Price Reporting Centre, CEIC

5.2 Provincial demand and supply/demand balances

Most indigenous gas is produced in western and central China, while most gas consumption takes place in the eastern and southern parts of the country. As a result, only six of the thirty provinces and municipalities shown in Figures 38 and 39 below actually have a gas surplus. The rest are in deficit and need to source gas supplies either from other provinces through the domestic long-distance pipeline network or via imports of gas through pipelines from Central Asia and Myanmar as well as through the increasing number of LNG terminals on China's south and east coasts. One of the major influences on future gas demand at the provincial level, apart from the absolute and relative levels of the gas price, is the structure of demand in the province while the availability and development of gas infrastructure is also a key determinant of future growth. With gas consumption rising at a consistently faster rate than gas production, this mismatch between production and consumption at the provincial level is only set to get worse over time, just as it does on a national scale.

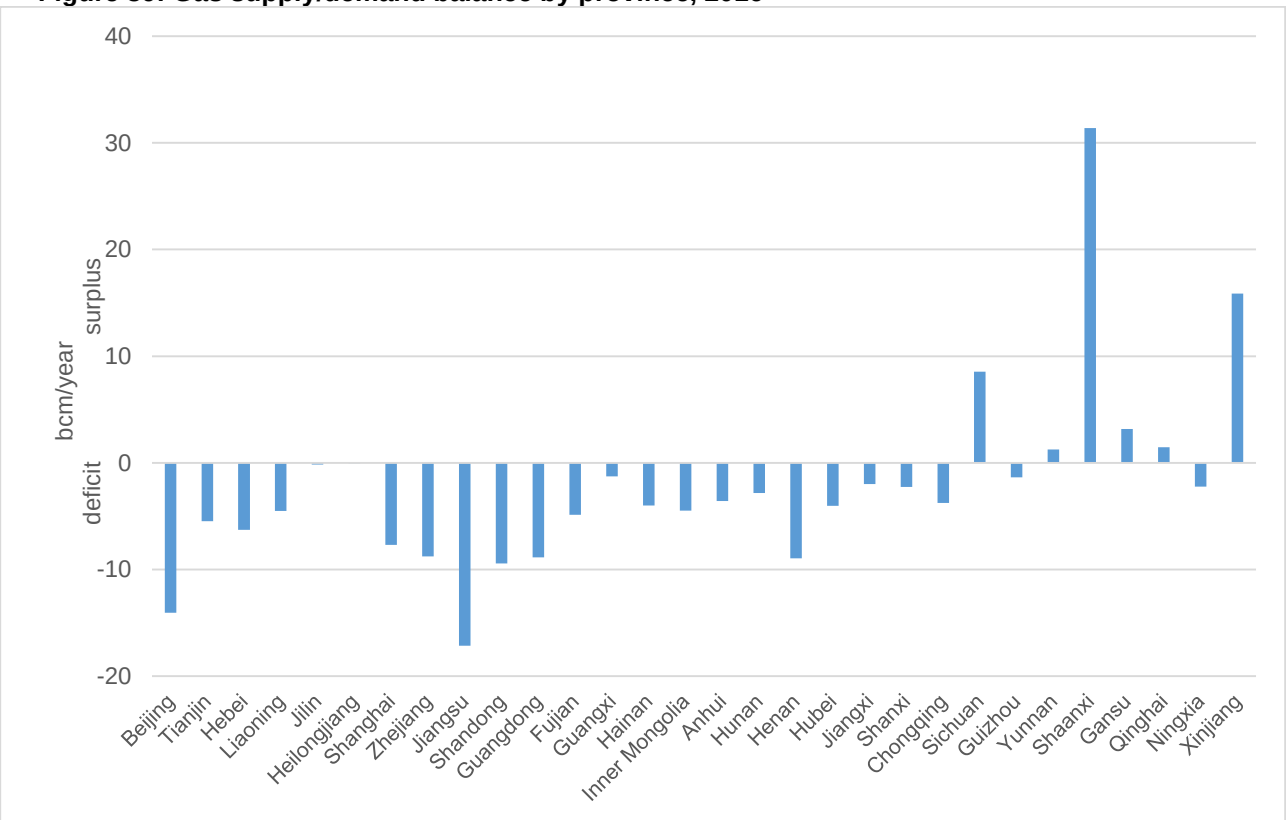
[192] World Gas Intelligence 14 February 2018
[193] NDRC data, cited by CEIC

Figure 38: Gas demand by province, 2016



Source: National Bureau of Statistics, CEIC

Figure 39: Gas supply/demand balance by province, 2016



Source: National Bureau of Statistics, CEIC

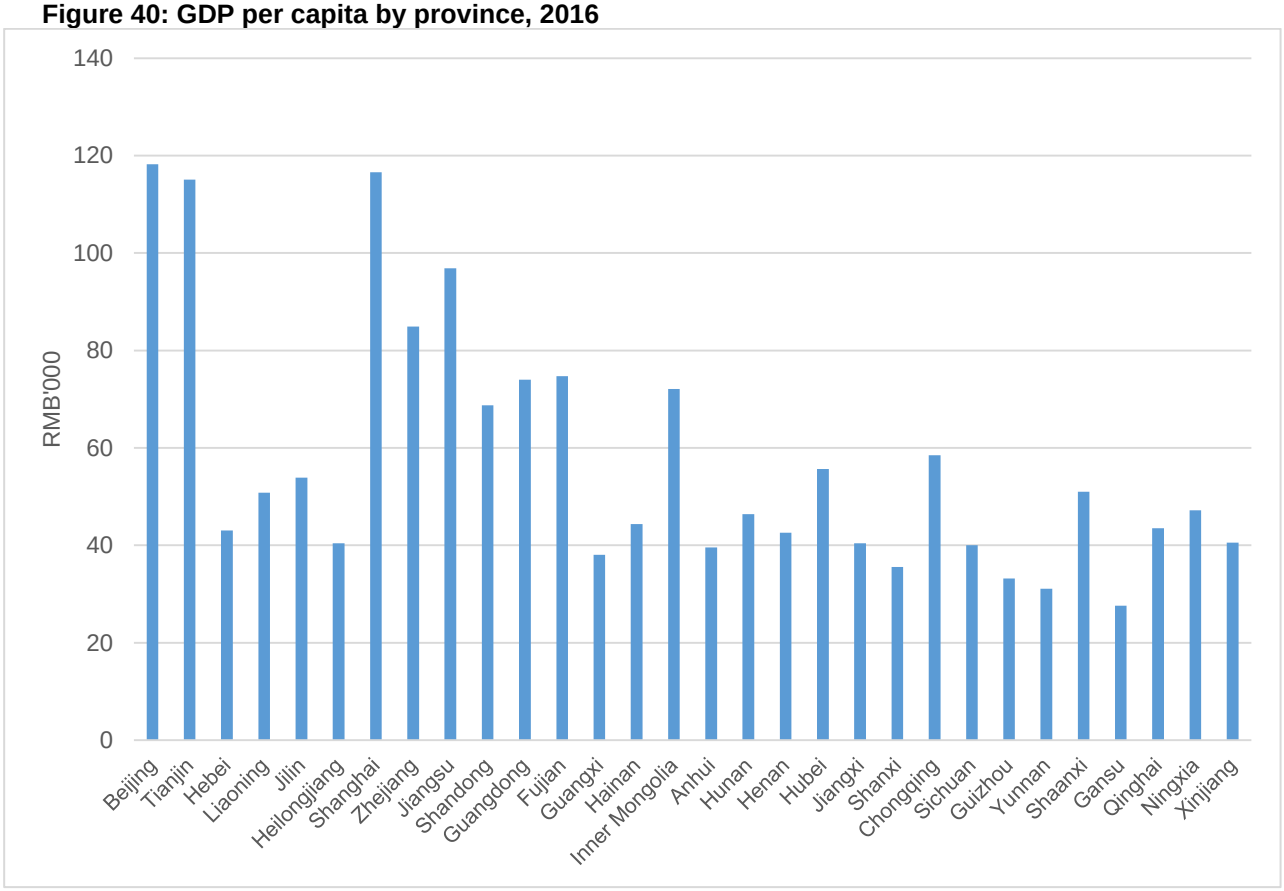
On a sectoral basis, the IEA notes that industry is the largest source of demand in all regions except Beijing. Residential use is the largest demand sector in Beijing. Energy use in transport is also closely correlated with GDP and is therefore highest in the eastern and central provinces.[194] Similarly, the proportion of different fuel types varies across regions. As an example, the IEA notes that the share of coal in overall energy demand is highest in the central region while the share of gas is highest in areas with domestic production or close to import routes such as Sichuan and Guangdong.

5.3 GDP and consumers' ability to pay

There is a very wide disparity in per capita GDP between provinces across China and, as such, consumers' individual ability to pay for the gas they consume. Notwithstanding that energy costs still represent a relatively small proportion of household expenditures, willingness and ability to pay for gas is an important factor that the government undoubtedly considers when determining the pace and extent of pricing reform across China.

Figure 40 below illustrates the disparity in per capita GDP across China. The richest municipality (Beijing) is more than four times wealthier than the poorest province (Gansu in western China). Illustrating the scale of the disparity between provinces, the median province (Hunan in southeastern China) has per capita GDP just 40% of the level of Beijing while just 11 of the 31 provinces and municipalities have per capita GDP above the Chinese average, reflecting the very skewed wealth distribution towards the large urban centres such as Beijing, Shanghai and Tianjin, all on the country's east coast.

Figure 40: GDP per capita by province, 2016



Source: National Bureau of Statistics, CEIC

[194] International Energy Agency World Energy Outlook 2017

5.4 Conclusions

We conclude that these price differentials arise as a result of:

- Different abilities to pay on the part of individual provinces and cities
- The competitive environment vis-à-vis the availability of other fuels (whether indigenous or imported)
- The degree of commitment (or otherwise) on the part of provincial and local authorities to implement the central government's reform priorities – including pricing reform.

Across the country our conclusion is that government policy will likely remain the key driver of gas demand in the short to medium term, both nationally and region by region, while gas pricing will drive demand once the impact of government policy diminishes as the coal-to-gas switching programme across China runs its course.

Northern China was the focus of the coal-to-gas switching programme in 2017 while 2018 appears to be following the same trend. We would expect to see the policy expanded over time to the central and southern parts of the country to increase the use of gas, replace coal and improve the environment. At that stage, the relative price of gas against other fuels will probably become the key determinant of gas demand in China.

6. Issues outstanding with gas pricing policy in China

In this final section we identify the most significant changes that have taken place in China's gas pricing framework over the past few years. We also review the issues which remain outstanding and which prevent China from having a completely market-based pricing framework in the gas sector.

6.1 Positive developments to date

The changes to China's gas pricing approach over the past few years have certainly had a positive – if still somewhat limited - impact on the structure and operations of the sector.

In summary, the major positive developments have been:

- Overall the price control regime in China has been relaxed and become less regulated
- The pricing mechanism itself has changed considerably, particularly for non-residential prices
- Residential price tiering is being succeeded by deregulated prices in the residential sector, albeit with a time lag before upward adjustments can be made
- Cross-subsidization of residential prices by industrial users will likely be eliminated or significantly reduced as residential prices are deregulated, although strong oversight may be required to ensure that this does in fact happen
- A framework for carbon pricing is developing in China.

There is no question that price controls have been relaxed to some degree. Market prices have replaced government-imposed prices as one of the key influences on the setting of citygate prices in China. Market prices, when used properly – and we have yet to reach that position in China - are more likely to stimulate a market response, contrary to the previous system where the government was involved with pricing at all stages of the gas chain.

The pricing mechanism itself has changed considerably over the past few years with the basis moving from 'cost plus' to 'market minus'. Citygate prices are in theory no longer built up on the basis of costs along the value chain but are instead derived from market-linked pricing at the citygate end with costs along the value chain deducted to arrive at the price that gas producers can charge. This approach is only partially effective as we have addressed earlier in this report.

In the politically sensitive residential sector, even though prices have barely changed over the past five years, a more commercial approach emerged with the introduction of price tiering and now the move to deregulate residential prices beginning in mid-2018. The need for market pricing appears to have trumped social stability, perhaps because of greater overall affordability of gas in China.

While not explicitly a gas pricing issue, in our view carbon pricing is an integral part of both pricing and the broader reform process. China has just begun the process of implementing a carbon market. At the end of 2017 the government announced the first stage of a market, focusing initially on just the power and heating sector – which overnight became the world's largest carbon market. These sectors are the largest carbon dioxide emitters across China, which has been running trials in seven provinces to prepare for the implementation of a cap-and-trade system. Companies are already preparing to respond to the government's plans. Having initially set a cap on carbon dioxide emissions, the government could lower the cap over time by amounts small enough to increase the cost of emissions to discourage polluters but not radically destabilize the power sector – and other sectors as the cap-and-trade model is introduced to them as well.

6.2 Outstanding issues

While a number of steps have been taken towards a market-based pricing system, there is still some considerable way to go and we assess below the remaining challenges to China's gas pricing reform process. These will need to be overcome before China's gas pricing system can be viewed as being broadly market-linked and commercially sustainable for the gas sector.

In summary, they are:

- The limited role that the pricing formula actually plays in setting prices – which will become increasingly important as gas begins to compete with coal in the large power generation market
- The lack of transparency surrounding the operation of the formula and the timeliness of price adjustments. Prices are set by the government but no end point or timescale for review or amendment is defined
- The absence of any incentives to build storage, a critical need in China
- A lack of progress on other aspects of gas sector reform – such as TPA and upstream liberalization - which impinge on gas pricing
- Government continues to face a key dilemma in pricing gas in a still-regulated market: low prices to encourage consumption and improve the environment or high prices to encourage domestic production and reduce import dependency.

Pricing formula is just one of the factors determining prices

In general, while the pricing formula is a good step forward, in reality it is just one of the factors that the government takes into account when determining price changes (which are still effectively therefore ultimately under the control of the government). The prices suggested by the pricing formula are just that – suggestions. They do not direct the timing of citygate price changes, nor their scale. There is very little transparency on the timing or size of these price changes – the foundation of the international price-linked pricing system. The actual calculations themselves are also opaque, despite the fact that the details of the formula itself are clearly set out in NDRC documents and work by Paltsev & Zhang using realistic assumptions has generated a degree of confidence in the workings of the formula.

The other concern about timeliness is the sometimes lengthy delay between the announcement of a change in the regulated citygate price and the actual price to the consumer – which affects the level of final demand – changing. (In some cases, particularly utilities owned by energy companies, price reductions are not passed on to the consumer).[195] Partly this is because of the requirement for pricing bureaus to approve any end-user price change and partly because of a desire on the part of local governments to keep prices down, which has the effect of squeezing city gas distribution companies' margins unreasonably.

Transparency and timeliness of price adjustments remain issues

Confidence in the government's pricing approach would be enhanced were more complete information about the underlying inputs and calculations to be made available. This is a particular issue when international oil prices fall but the domestic gas price – linked to those international oil prices – remains unchanged because of delays in implementing revisions suggested by the pricing formula. With gas becoming relatively more expensive compared to oil as a result, gas demand is

[195] Discussion with energy analysts in China March 2018

adversely affected by the price disparity and this frustrates government policy objectives of increasing gas use to improve the environment.

There is no provision in the current pricing framework that incentivizes the construction of additional storage capacity, one of China's serious gas infrastructure failings. However, unless there is price volatility, storage is unlikely to be a successful business. Much depends on the rationale for storage – which at the moment appears to focus on the need to stabilize prices and ensure supply security. With that rationale in mind, additional storage capacity is most likely to be constructed if it is operated by a state-owned company or the NOCs are forced to build storage capacity to a predetermined level linked to their domestic sales.

Seasonal pricing has become a factor in China's gas market in 2016 and 2017 and looks set to return in 2018. Following the 2015 price cuts, the government prohibited price rises for a year. Once that period had passed – in November 2016 - the Chinese oil companies raised wholesale prices temporarily by 10-15% to address the impact of heavily seasonal demand among users as winter approached. Similarly in late 2017 another price rise was imposed by PetroChina, effectively a 10-20% increase depending on the volumes of gas being consumed. With 2018 price rises under discussion, these temporary price movements could become an accepted part of the country's demand management process unless and until additional gas storage capacity is constructed.

Broader sector reform continues to move slowly

There has been very limited progress on other (non-pricing) aspects of gas sector reform. Competition continues to be restricted in the upstream and midstream segments. The three major NOCs control most of China's natural gas production and virtually all of the country's long-distance gas pipeline network, storage and LNG import terminals. Third party access to this infrastructure is an essential part of gas sector reform and, while it has been frequently discussed, little concrete action has been taken to implement anything meaningful. If gas consumption is really to be encouraged through market forces, then greater competition between gas suppliers – to drive efficiency gains – and access to national infrastructure by private companies – to deliver lower prices to end-users – is essential if prices are to be structurally lowered, rather than supported by government subsidy, to encourage that consumption. Put simply: more competition leads to more affordable gas which in turn leads to an increase in gas demand.

7. Conclusions

China's Five-Year Energy Plan is focused on increasing the use of natural gas (and other energy sources) at the expense of coal. Within it there is a particular focus on gas sector reform, of which price reform is a critical element. Apart from the financial need to put the gas sector on a sustainable commercial footing, one of the main driving forces behind the desire for greater gas use is to improve the environment by reducing the use of coal and replacing it with gas and other low-or zero-carbon energy sources.

Pricing is not the only challenge facing China's gas sector

In addition to pricing reform, there are infrastructure challenges to be overcome, structural reform is needed in the upstream and downstream sectors and gas hubs need to develop to aid price discovery and transparency.

Challenge from renewables

A serious issue on the horizon for the gas industry in China is the growing challenge from renewable energy. In our view there is a limited window of opportunity for gas to establish itself as a major source of energy in China. It faces a challenge over the next decade to establish itself as an important enough source of energy to withstand the competition from renewables, a challenge highlighted when gas was described as 'a bridge fuel to a renewables future'.

Demand growing faster than supply

While China's own domestic gas production has been growing, it is doing so at a slower rate than demand. Unsurprisingly, keeping gas prices low to encourage demand growth has indeed encouraged gas demand while disincentivizing supply growth – and this is likely to have a more significant impact in future as the Chinese government moves away from controlling all prices towards a more liberalized market where the ability to subsidize the companies' gas production will be sharply curtailed.

Imports are loss-making

Imports of natural gas continue to be loss-making for the NOCs, based on the evidence of PetroChina's 2017 and first half 2018 financials and the domestic price cut imposed in September 2017 will only have worsened the position in 2018. Hence we have seen government pressure on pipeline tariffs – rate of return caps for example – as a way of reducing the cost of gas to end-users without creating a linked opposite effect on the gas producers themselves. While the NOCs currently own the pipelines, more transparency is being mandated and the eventual aim is to create a national pipeline company based on their pipeline assets but separate from the NOCs.

Government policy, not pricing, is the key demand driver at present

The evidence suggesting that lower prices have significantly stimulated gas demand in China is mixed. There is undoubtedly some impact from lower gas prices but government policies and economic growth appear to have had a significantly greater impact on gas demand in recent years. The particularly strong growth seen in 2017 was largely the result of government policies supporting the growth of gas usage and coal to gas switching– although there was a price cut in September. The outlook for 2018 is also looking quite strong, based on first half actuals, and government policy remains supportive of the coal to gas switching programme. The longer-term outlook will be affected not just by the path of price reform but by government policy, economic growth, the advance of renewable penetration in China's energy mix and the overall gas sector reform process itself.

Nevertheless, price reform in China's gas industry is increasingly necessary to encourage greater domestic production and to help stem the losses incurred by the NOCs when selling imported gas in the domestic market.

Government has to strike a balance between the environment and supply security

The government has a balancing act to maintain. To increase the use of gas and improve the environment, it needs low prices for gas, both in absolute terms and in relative terms against competing fuels, to encourage consumption. On the other hand, it also needs prices that enable producers, importers and distributors to make money so that they can invest in their businesses and ensure energy security. Some aspects of these prices are under the government's control – such as subsidies and the rate of return allowed on the gas distribution pipelines – while others, such as the cost of gas imports (up 34% in volume terms and 65% in value terms over the first nine months of 2018) are largely outside its control.

Substantial progress made but a lot still to do

On balance, we can conclude that over the more than decade long period from 2005 to 2018, and with progress seemingly moving more quickly in the last five years, China's gas pricing policy has moved away from one set entirely by government to one influenced more or less significantly by the market. The most recent announcement, that residential prices were to be deregulated, is the latest sign that progress towards the ultimate goal of a market-priced gas sector continues – albeit on an unpredictable timescale.

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