



Global Gas/LNG Research

Current and Future Natural Gas Demand in China and India

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ESSENTIAL ACRONYMS, UNITS AND CONVERSIONS

Terms:	
CNG	Compressed natural gas
EIA	US Energy Information Administration. IEO is EIA's International Energy Outlook.
GOI	Government of India.
IEA	International Energy Agency. WEO is IEA's World Energy Outlook.
LNG	Liquefied natural gas; mainly methane, chilled under atmosphere pressure, to -256 F (Fahrenheit). See CEE's Introduction to LNG, http://www.beg.utexas.edu/energyecon/INTRODUCTION%20TO%20LNG%20Update%202012.pdf
LPG	Liquid petroleum gas, mainly propane; may have butane present.
Natural gas	A hydrocarbon mixture that can include a variety of molecules including methane (one carbon and four hydrogen atoms, CH ₄), ethane (two carbon atoms or C ₂), propane (C ₃), butane (C ₄), pentane (C ₅) and other forms and compounds that result in variation in molecular size and weight. The most common reference to natural gas in this paper is methane. See http://naturalgas.org/ for basics and descriptions of natural gas value chain segments and facilities and natural gas occurrence, and http://www.beg.utexas.edu/energyecon/GlobalGas-LNG/ for similar background relative to LNG development, safety and security.
NBSC	National Bureau of Statistics, China
NGLs	Natural gas liquids, including C ₁ – C ₅ (methane, propane, butane/isobutane, pentanes).
Units and conversions:	
Natural gas quantities in cf, Btu, cm	A cubic foot, cf , of natural gas is the volume per cf at standard (normal) temperature (60 degrees Fahrenheit) and pressure (sea level). A cf of natural gas that is entirely methane, gives off about 1,011 British thermal units (Btus) per cf. Energy (heat) content varies with natural gas composition. Natural gas heat values can range from 950 to 1150 depending upon molecular composition (see http://www.engineeringtoolbox.com/heating-values-fuel-gases-d_823.html). Natural gas volumes in metric are expressed in cubic meters or cm . Natural gas volumes in this paper are measured in thousand (M), million (MM), billion (B), trillion (T). Average throughput associated with natural gas facilities (the volume of natural gas moved through facilities such as pipelines, underground storage and LNG trains, storage and regasification is expressed generally as volumes "per day" or "cf/d" or for metric "per annum" or cma. One billion cubic feet or Bcf of natural gas converts to metric, one billion cubic meters or Bcm, using a multiplier of 0.028. The BP Statistical Review of World Energy, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html includes useful conversion factors and data.
LNG quantities in t, tpa	Tonnes of LNG, t , a measure of LNG facilities' capacity and tonnes per annum, tpa , a measure of throughput from LNG facilities. LNG facility capacities and throughput are most commonly expressed as million tonnes, mt , and million tonnes per annum, mtpa . A Bcf of natural gas converts to 1 mt of LNG with a multiplier of 0.021 (rounded). A Bcm of natural gas is converted to 1 mt of LNG with a multiplier of 0.74 (rounded).
Bbl, BOE	Standard 42-gallon barrel, or Bbl , of crude oil, liquids, or oil equivalent (expressed as barrel of oil equivalent or BOE).

See EIA Glossary for more information. <https://www.eia.gov/tools/glossary/>

See BP Annual Statistical Review for typical conversions.

<http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>



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PREFACE

This research paper is part of a body of work undertaken to better understand demand for natural gas in key world regions and implications for natural gas trade over the next 20 years. The research is being conducted by the Bureau of Economic Geology's Center for Energy Economics, The University of Texas at Austin, with external collaborators and peer reviewers. Research and preparation of this paper was led by Miranda Wainberg, Senior Energy Advisor and Michelle Michot Foss, Chief Energy Economist and Program Manager with extensive support from Gürcan Gülen, Senior Energy Economist and Research Scientist and Danny Quijano, Economist and Research Associate.

To address the complexity of these large and dominant markets, the CEE team took several steps: a research seminar on China in March 2015; presentation of research concept and early observations at the World Gas Conference in Paris, June 2015 (by Dr. Michot Foss); a research seminar on Asia natural gas trends with a focus on China and India in September 2015; and a research seminar on initial findings and draft conclusions on the combined China/India report in May 2016 (along with review of a separate report on global LNG supply trends by Andy Flower, including Mr. Flower's own views on China and India energy and natural gas developments). Peer reviewers for this paper were: Dr. Michelle Michot Foss, Principal Investigator for CEE's global gas and LNG research; Dr. Gürcan Gülen, research scientist and senior energy economist; Mr. Guy Dayvault, Energy Deal Solutions; Dr. Donald Knop, CEE analytics and modeling advisor; Dr. Bhamy Shenoy, CEE India/Asia advisor; and Ms. Deniese Palmer-Huggins, CEE senior energy advisor.

Preparation of this paper benefitted from past CEE research team project experience in China and India, including work funded through the U.S. Agency for International Development (USAID), as well as broad and diverse research and projects related to natural gas and LNG development and use in roughly 20 countries over the years. Readers are invited to explore CEE's Global Gas and LNG page, <http://www.beg.utexas.edu/energyecon/GlobalGas-LNG/>, for a summary of experience and outputs. The research team benefits from a broad network of collaborators with whom we maintain ongoing exchanges. In particular we recognize the following: research staff at the IEA, who were generous with their time on historical and outlook data series; The Energy Research Institute (TERI) in India which helped with current data gathering; Professor Xiaojie Xu, a long-time CEE collaborator, Institute of World Economics and Politics, Chinese Academy of Social Sciences; colleagues at the Oxford Institute for Energy Studies, with whom we've had many interactions on these geographies; and the many energy industry and government professionals who engage with us on a regular basis, in separate meetings as well as our periodic seminars and regular annual meetings, as we perform our work.

Undertaking a deep exploration of patterns of energy use requires a strong dose of "data courage". For all of their size, market and political heft, China and India are woefully short in data transparency. The result is a vast landscape of unreliable analysis, outlooks and forecasts upon which crucial decisions are made. It also means that the governments themselves do not have the necessary information streams to underpin the kinds of policy and regulatory strategies that are incumbent upon them in our modern age. Whether the lack of timely and transparent data is intentional is not for us to say. The consequence is a divergence between what could and what should be expected with respect to potential outcomes, adding to the risks and uncertainties inherent in energy systems today.



INTRODUCTION

Natural gas is expected to play an increasingly larger role in global energy portfolios owing to its increasing abundance via pipelines and, especially liquefied natural gas (LNG), and its lower emissions. China and, to a lesser extent, India have been seen as leading drivers of demand for natural gas. Together, these two countries account for roughly a third of world's population. Rapid economic growth in these countries, especially China, in the 2000s was the locomotive of the world economy. However, China (along with Brazil and Russia) has recently experienced a significant decline in gross domestic product (GDP) growth.

In this report, we investigate the potential for natural gas demand growth in these countries within their macroeconomic context, existing and emerging natural gas industry trends, and, most importantly, commercial frameworks within each country that can facilitate or hamper the development of a vibrant natural gas sector.

Both countries rely heavily on central planning rather than on markets and both countries have large bureaucracies and rely heavily on state owned enterprises (SOEs). Both countries give lip service to increased private sector economic participation and a smaller economic role for the state, and to increased reliance on market forces.

India has tended to utilize the import substitution model of economic development. China has followed the East Asian export promotion model of economic development. Consistent with the relative success of those models elsewhere the Chinese approach has been more far more successful than the Indian approach. China has grown much more rapidly, especially in the decade before the great recession and has significantly higher per capita income.

India is more agrarian and has a smaller industrial sector though it does have a larger service sector. India plans to increase the manufacturing share of GDP. Indian GDP growth is expected to continue to average about 5 percent though that depends on successfully increasing its manufacturing sector share. There is no reason to expect India to duplicate the double digit growth rates that China achieved prior to the great recession.

China's export promotion model resulted in rapid growth in both GDP and energy and other commodities. China is now attempting to shift to a more consumption based economy. That means much lower GDP growth and significantly lower energy and commodity demand growth due to the lower GDP growth and falling energy and commodity intensity of GDP. China's economic growth has slowed significantly from double digit rates prior to the great recession to the 6 to 7 percent range. Many analysts think the current growth rate may be even lower.

Future Chinese GDP growth is expected to average 5 to 6 percent. The transition to a consumption based economy is likely to take a number of years, and there is considerable question how smoothly the planned transition to slower growth and a more service and consumer oriented economy will go and how long it will take. A "hard landing" has been avoided thus far but that does not mean that it will be avoided. China is not likely to return to double digit GDP growth rates that were the norm a few years ago.

Economic growth has led to serious urban air pollution problems in both India and China, which they are attempting to address. Although environmental issues could lead to increased demand for natural gas at



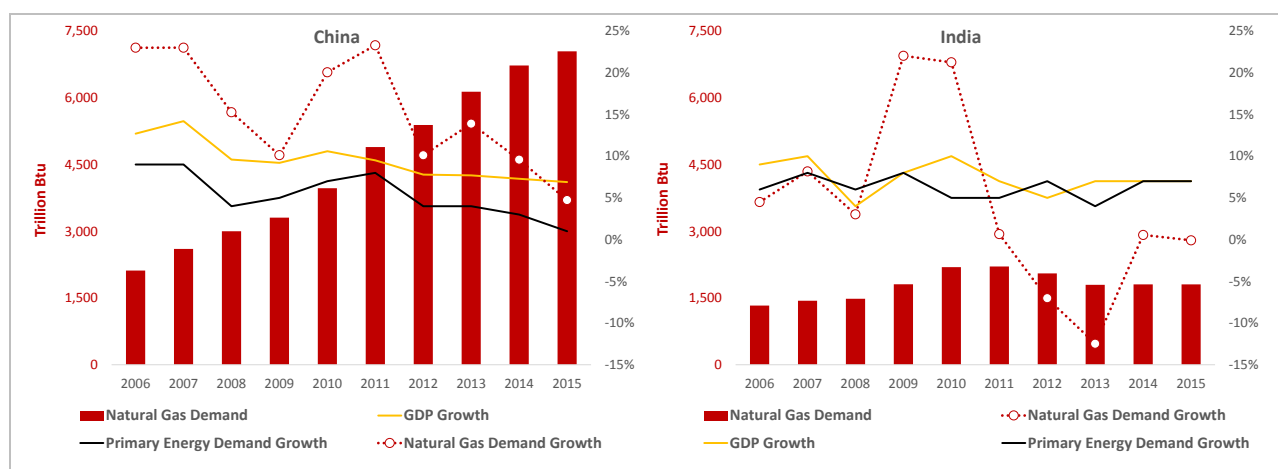
the expense of coal, it is not clear how much either country is willing to pay to internalize environmental externalities, including those associated with carbon.

India and China GDP growth projections may prove too optimistic unless the global economy is able to approach its pre Great Recession growth rates. China probably is the most vulnerable to weak global growth given its higher reliance on export markets.

MACROECONOMIC CONTEXT FOR NATURAL GAS IN CHINA AND INDIA

Economic growth is a necessary but not sufficient condition for energy consumption in general and natural gas consumption in particular. Natural gas demand growth in both China and India are no exceptions. Although primary energy consumption growth has been more closely related to economic growth in each country, natural gas demand growth has been more erratic (Figure 1). Correlation between GDP growth and primary energy demand growth in India is only 0.08 although the correlation between natural gas demand growth and GDP growth is higher (0.56). In contrast, these correlations are much higher in China and consistent with each other: 0.89 (GDP-primary energy) and 0.83 (GDP-natural gas). Although one should not read into these simple correlations too much, especially given the notoriety of data accuracy from these countries, they indicate a fundamental difference in two countries' energy-economy dynamics. In China, the relationship seems to follow the conventional path of industrial economy while in India, the lack of widespread industrialization and large use of non-commercial biomass appear to cloud the energy-economy relationship.

Figure 1. GDP Growth, Primary Energy and Natural Gas in China and India



Notes: Natural gas demand on left axis, growth rates on right axis. The average annual growth rates for the period 2005-2015 were 7% (India) and 10% (China) for GDP, 6% (India) and 5% (China) for primary energy and 4% (India) and 15% (China) for natural gas. Sources: World Bank, BP Statistical Review 2016, CEE estimates.

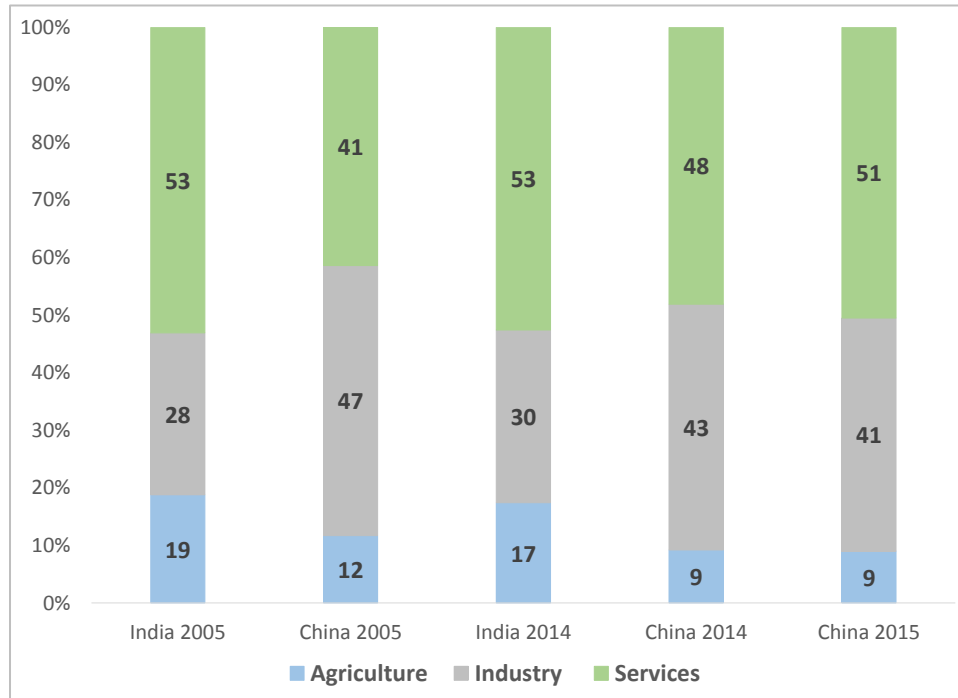
The electric power and industrial/commercial sectors account for over 60% of total natural gas demand in both countries. Industry/commercial is by far the largest consumer of electricity in both countries: 72% in China in 2015 and about 55% in India in 2014. Residential gas demand, the next largest gas consuming sector, is driven by increasing urbanization which in turn is linked to economic growth.

Composition of GDP and Employment Structure

Both China and India want to find new drivers of economic growth. China is in the midst of transitioning from a heavy industry-oriented and export driven economy to a services-oriented and consumer driven

economy. India, on the other hand, has transitioned from an agriculture-heavy economy to a services-oriented economy in the 2000s and now wants to substantially increase the role of manufacturing (Figure 2).

Figure 2 – Composition of GDP in China and India (Value Added by Sector)



Source: World Bank World Development Indicators; National Bureau of Statistics China. Industry includes the electric power sector.

The structure of India’s economy has changed little since 2005: its focus has been on domestic consumption in a services-led economy (53%) with subdued industrial participation (30%) and a large agricultural sector (17% versus 9% for China). In the industrial sector, manufacturing value added was only 17% versus 32% for China.¹ Unlike many other countries, India’s services-led growth was not preceded by a strong initial manufacturing push. In addition, agriculture plays a much larger role in the Indian economy: it employs more than 50% of the population but has low productivity with value added as a percentage of GDP of only 17%. The economically dominant services sector, in contrast, employs only about 25% of the population of India.

China, on the other hand, has been a manufacturing-led economy focused on exports. This orientation was reinforced by heavy government spending after the 2008 financial crisis which fueled a construction boom for factories, housing and infrastructure.² China began trying to steer its economy away from heavy industry and construction and in 2012 value added by services (45.5%) surpassed that of industry (45%) for the first time with services value added increasing to 51% in 2015.³

¹ The standard definition of “industry” or “secondary industry” includes electric power generation and construction in addition to manufacturing. We break out manufacturing because those entities are the natural gas consumers.

² Wildau, 2016..

³ National Bureau of Statistics China (NBSC).

In its 2015 World Energy Outlook (WEO15), the International Energy Agency (IEA) points out that industry-led growth requires at least 10 times more energy per unit of value added compared with services-led growth; the services sector is also more electricity intensive.⁴ In a services-led economy, natural gas demand growth relies more on power sector gas consumption to offset decreases in manufacturing gas consumption.

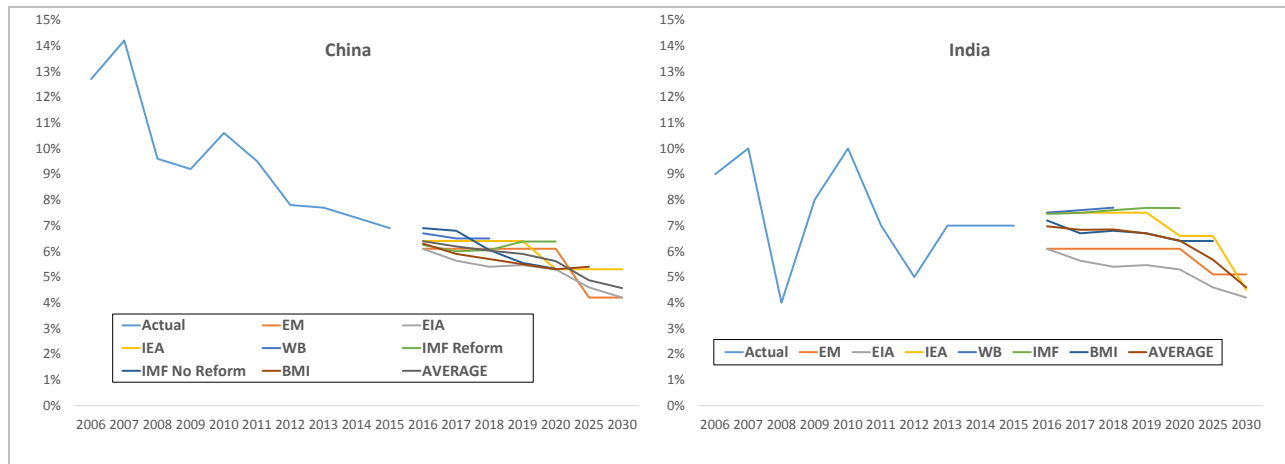
In both countries, the state is a significant participant in the economy, often through state-owned enterprises (SOEs) in key sectors such as energy. Both countries would like, in varying degrees, to see private sector economic participation grow and the economic role of the state reduced. There has been rhetoric in both countries about allowing, to some extent, free market forces to influence their economies.⁵

Both India and China are trying to make major structural reforms to their economies without heavily damaging GDP growth and employment in the process—a very difficult balancing act. To further complicate the process, economic growth has led to serious urban air pollution problems in both countries and the costs of addressing those problems are an additional burden on their economies. Although environmental issues could lead to increased demand for natural gas at the expense of coal, it is not clear to date whether either country is willing to absorb the full costs of carbon penalties.

GDP Growth and Industrial Structures in China and India

Forecasts of long term GDP growth are around the 6%/year level, some declining below that beginning 2020-2025 (Figure 3). Average growth between 2014 and 2035 is estimated at 5% in BP Energy Outlook 2016.

Figure 3. Historical and Forecasted GDP Growth Rates



Source: World Bank for actuals; ExxonMobil 2016 Outlook for Energy (EM); Energy Information Administration International Energy Outlook 2016 (EIA); International Energy Agency World Energy Outlook 2015 (IEA); World Bank Global Economic Prospects, 2016 (WB); International Monetary Fund Country Report No. 15/234 for China, World Economic Outlook for India (IMF); BMI Research China Oil & Gas Report Q3 2016 (BMI).

⁴ IEA WEO15.

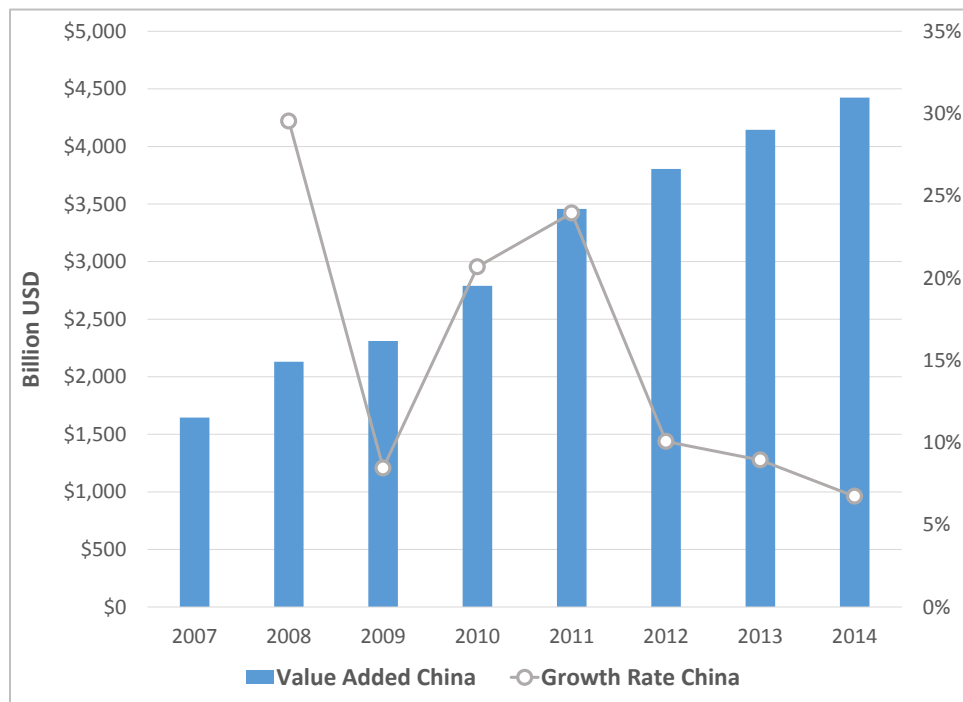
⁵ “Calibrated market freedom” is the Indian phrase.

China's GDP growth rate moderated to 6.9% in 2015, down from 7.3% in 2014, and government officials are forecasting a growth rate of 6.5% for 2016. The International Monetary Fund (IMF) expects GDP growth of 6.3% in 2016 and 6% in 2017 reflecting weaker investment growth as the economy continues to rebalance.⁶

Industrial overcapacity and debt in China

The value added to GDP by the industrial sector continued to grow in 2015 but at a lower rate (Figure 4). However, total profits for industrial enterprises decreased 2.3% in 2015 with industrial SOEs' profits falling 22%.⁷ In addition, industrial output continued to fall; the Caixin manufacturing China Purchasing Managers Index (PMI) has indicated a manufacturing contraction since March 2015 through June 2016.⁸ In fact, the PMI has been below 50 (indicating a contraction) most of the time since 2012. China's faster-than-expected slowdown in exports (25% year-on-year in early 2016) highlight the need for greater growth in domestic consumption to reach government GDP targets.

Figure 4. China Industrial Enterprises Value Added and Growth Rate (%)



Source: World Bank

China is struggling with massive overcapacity and high debt levels⁹ in its manufacturing sector: energy intensive steel, non-ferrous metals (aluminum, copper, bauxite), building materials (cement, glass),

⁶ IMF, World Economic Outlook Update, 1/19/16.

⁷ The SOEs are clustered in energy, steel, coal, shipbuilding and heavy machinery.

⁸ The Caixin manufacturing China PMI is derived from a survey of 430 industrial companies on five indexes that are then combined with the following weights: New Orders-30%; Output-25%; Employment-20%; Suppliers' Delivery Times-15% and Stock of Items Purchase-10%.

⁹ Macquarie Securities estimates that SOE debt at the end of 2015 was about 88% of GDP; private company debt was 55% of GDP (143% of GDP total corporate). Standard & Poor's estimates that corporate debt is 160% of GDP.



chemicals, and refining. If China significantly reduces capacity and output from these industries, it will have a negative impact on natural gas demand. Some of these industries will decline but the pace and magnitude of the declines are uncertain. Although the government recognizes the need to reduce overcapacity in these industries, progress has been muted to date due to government fears about unemployment and social unrest. Instead of closing the unprofitable SOEs that dominate these sectors, the government seems to be relying on mergers, reorganizations and debt restructuring to minimize “discomfort.”¹⁰ The number of SOEs continues to grow, increasing from 110,000 in 2008 to about 160,000 in 2014.¹¹

Government spending has been increasing in an effort to maintain growth and accounted for 36% of the investment in fixed assets in 2015. Central and local government debt as a percentage of GDP increased from 51% and 21%, respectively, in 2014 to 53% and 33% in 2015.¹² China’s total debt (government, corporate and household) has quadrupled since 2007 and was almost 250% of GDP at the end of 2015.¹³ In early 2016 the central government announced a series of actions designed to stimulate investment and spending including:

1. A reduction in the reserve requirements of banks, responsible for about 70% of all lending in China, in an effort to stimulate lending;
2. A reduction in businesses taxes (the central government will take over some local government debt as local government revenues will be reduced by the tax cut¹⁴); and
3. The central government will increase its budget deficit to 3% from 2.3% in 2015 to inject spending and investment into the economy.

These actions suggest that the “gradual rebalancing” of China’s industrial sector will be a prolonged process. At this time, the government appears unwilling to risk the social turmoil that could result from harsher and more immediate measures. It has launched the “One Belt, One Road” initiative with the hope that the infrastructure investment required by the project would be an outlet for some of China’s excess industrial capacity.¹⁵ However, there has been limited concrete progress (construction contracts signed, financings established) to date and critics maintain that there are many operational challenges to overcome, not the least of which is the coordination among multiple central government institutions,

UBS estimates that China’s total debt in January 2016 was 260% of GDP. Sources: *Wall Street Journal* 3/7/16, 2/25/16, 3/2/16 and 3/6/16; Moody’s 3/2/16.

¹⁰ *Wall Street Journal*, 3/5/16 and 3/8/16.

¹¹ Kroeber (2016).

¹² He, L., 2016.

¹³ *The Guardian*, 2016.

¹⁴ *The Wall Street Journal*, 3/7/16.

¹⁵ Goodman, 2004. The OBOR initiative was announced by President Xi Jinping in late 2013 with the dual objectives of (1) expanding China’s international presence and economic impact and (2) helping to absorb China’s massive industrial overcapacity and developing poor underdeveloped western provinces (Johnson, 2016). Some researchers like Johnson think that the domestic economic objectives are paramount. OBORs initial focus is building an economic corridor in Central and Southeast Asia along the geographic lines of the ancient Silk Road. Regional connectivity will be enhanced by building transport infrastructure and establishing industrial and financing projects. A \$40 billion Silk Road Fund backed by three large Chinese financial institutions, including its sovereign wealth fund, became active in 2015. The Bank of China plans to extend \$120 billion in credit to OBOR-related projects between 2015 and 2018. The Asian Infrastructure Investment Bank (AIIB) is also expected to finance OBOR construction. OBOR is the creation of President Xi Jinping and has his strong personal support.

multiple provincial governments, SOEs and private companies. Similar operational challenges hobbled previous “develop the west” initiatives like President Jiang Zemin’s Great Western Development campaign of the 1990s (Goodman, 2004).

In March 2016 Moody’s changed the outlook on China’s sovereign debt rating from “stable” to “negative” citing further possible fiscal weakening if underlying economic growth, excluding policy-supported economic activity, remained weak.¹⁶ Moody’s singled out “high and rising” SOE leverage as increasing the risk of a sharp economic slowdown and/or further deterioration of bank asset quality. However, Moody’s did point out that the Chinese government has some time and room to maneuver as large domestic savings continue to fund government debt at affordable levels. The IMF said in August 2015 that stabilizing near-term GDP growth at around 7% by relying on the old growth engines of credit and investment could lead to a protracted period of significantly slower growth post-2017 (IMF No Reform in Figure 3).

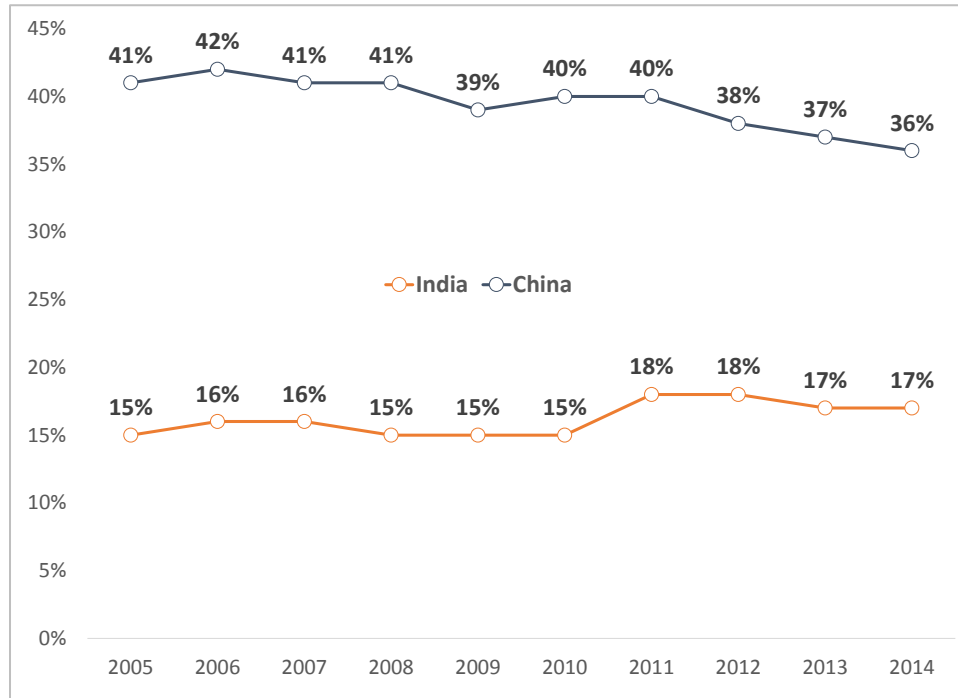
Overall the “rebalancing” of the industrial landscape in China is negative for natural gas demand. Key developments to monitor include government policies that affect the pace and magnitude of the slowdown in energy intensive manufacturing such as mandated capacity reductions, bank lending and other financing policies, SOE restructuring, local government policies that may be inconsistent with central government initiatives, subsidy levels, global trade actions that affect exports and the level of government investment in and support for these industries.

India’s Plans to Increase Share of Industrial Output

India’s development path has been different from that of China (and those of many other countries). Typically, economic growth follows a path from agriculture to industry and then finally to services. In contrast, Indian economy grew fast, especially since the early 2000s) on the basis of the services sector with the industrial sector trailing. As a result, the share of manufacturing in GDP remained in the range of 16-17% in India while it was more than 40% in China in the mid-2000s although the maturing economy in China with the help of an emerging middle class started to shift to services and the share of manufacturing declined to 36% by 2014, still more than twice as large as in India (Figure 5).

¹⁶ Moody’s, 3/2/16.

Figure 5. Manufacturing Value Added as Percentage of GDP



Source: World Bank World Development Indicators

Although India’s GDP has been growing (previous Figure 3), China’s GDP is five times the size of India’s (\$10 trillion versus \$2 trillion) and India’s GDP per capita is low relative to other emerging economies, one fifth of that of China. Note, however, that in terms of purchasing power, the differences narrow according to the World Bank statistics. Chinese GDP in PPP terms is only 2.5 times as large as India’s GDP; and Chinese GDP per capita is only 2.3 times as large. The last poverty rates, measured as percent of population living on \$3.10/day or less in purchasing power terms, reported for the two countries by the World Bank (World Development Indicators) were 58% for India (2011) and 27% for China (2010).

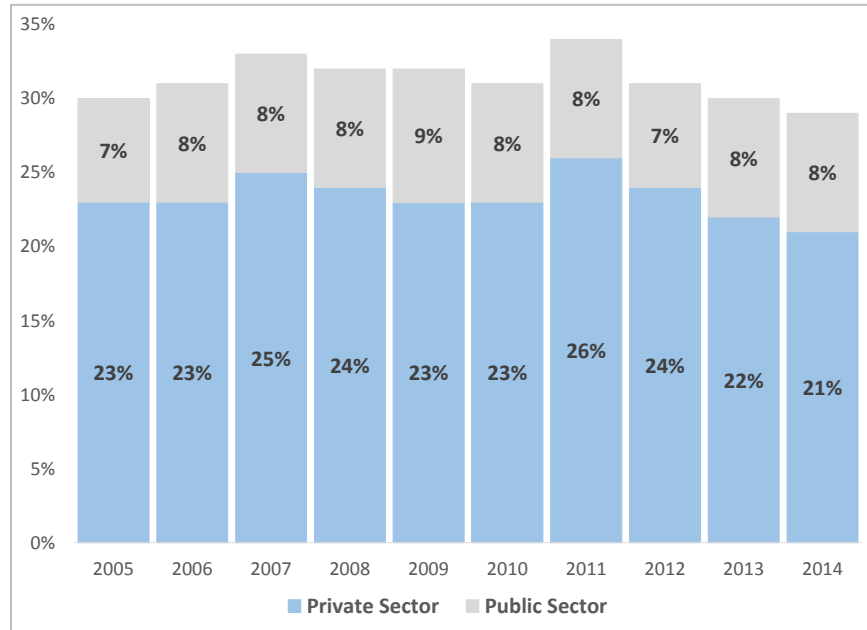
As such, India’s economic growth issues are quite different from those of China. Instead of trying to curb runaway industrialization like China, India wants to increase the role of manufacturing in its services-led economy from 17% of GDP value added in 2013 to 25% by 2022 and adding 100 million jobs to the sector (Figure 5). The Modi administration has a specific “Make in India” policy to support that goal. There is a growing realization that services-led growth is not delivering the employment opportunities needed by India’s expanding labor force.¹⁷ If this manufacturing policy is successful, particularly in energy intensive sectors such as chemicals, steel, aluminum, paper and cement, demand for natural gas should grow more rapidly than it has done in the past.

There are challenges facing India’s “Make in India” manufacturing policy. Both public and private capital investment have been weak (Figure 6) reflecting high leverage and weak profitability in the corporate sector, limited lending capacity and continued asset quality deterioration in the banking sector and the limited ability of the central government to make much needed economy-stimulating investments.

¹⁷ Government of India, Economic Survey 2014-2015.

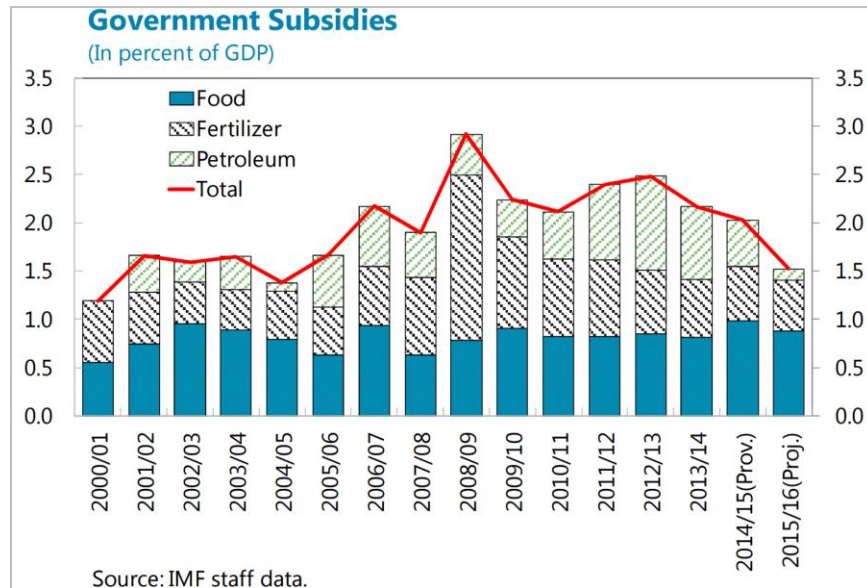
India's gross fixed capital formation averaged 31% of GDP from 2005 through 2014 compared to 40% in China and its growth rate was about 4% p.a. 2012-2014.

Figure 6. Gross Fixed Capital Investment in India as Percentage of GDP



Source: World Bank Development Indicators

Figure 7. Subsidy Burden in India



Source: IMF staff data.

Source: IMF Country Report 16/75, page 68, March 2016

With respect to government investment, India is constrained by a relatively high total government debt (66% as of early 2015 compared to about 42% for China at the same time¹⁸) and a subsidy burden equal

¹⁸ Trading Economics, Government Debt to GDP, <http://www.tradingeconomics.com/china/government-debt-to-gdp>.

to about 2% of GDP.¹⁹ As a result, interest expense and subsidies account for about 40% of total government spending and capital expenditures account for about 15%.²⁰ Subsidy expenditure has begun to decline as India has eliminated and reformed certain subsidies and other subsidies have decreased with crude oil prices (Figure 7) and is expected to fall 3% in 2016-17.²¹ Government capital expenditures are budgeted to increase a modest 3.9% in 2016-17, following a 21% increase in 2015-16, for investment in ports, roads, rail, irrigation and other infrastructure projects. This level of investment was a disappointment to many in the business community but India is under some pressure to contain its fiscal deficit.²² The weak private investment picture is partly explained by the large inventory of stalled projects in India (Table 1), which was equivalent to 6.9% of GDP at the end of 2014: 5.5% in the private sector and 1.4% in the public sector.²³ The overhang of stalled projects limits new capital investment.

Table 1. Stalled Projects (by value) as a fraction of GDP

Year	Government	Private	Total
2011-12	2%	5.7%	7.7%
2012-13	1.9%	6.1%	8.9%
2013-14	1.8%	6.5%	8.3%
2014-15(till Q3)	1.4%	5.5%	6.9%

Source: GOI Economic Survey 2014-15.

Most of the stalled projects in the private sector are in manufacturing, including steel, cement, garment and food processing. As a result, the value of new investment projects minus the shelved projects are reported as negative in many quarters during 2013 and 2014 (Figure 8). Most of the stalled projects in the public sector are in the power sector and non-financial services; manufacturing forms the major component of stalled projects in the private sector.²⁴ The top reason for stalling in manufacturing projects is poor market conditions, including weak demand.²⁵

Electric generation projects in both the public and private sectors are stalled due to fuel curtailment (coal and natural gas, at subsidized prices) and the near bankruptcy of many electric distribution companies.²⁶ In later sections we discuss India's fuel pricing policies and implications for both fuel curtailments (supply) and infrastructure. Public projects also are stalled due to land acquisition problems, lack of non-environmental clearances due to "policy paralysis" and lack of funds.²⁷ Private projects are stalled due to unfavorable market conditions, lack of promoter interest, and lack of non-environmental clearances.²⁸

¹⁹ The Chinese government does not report its subsidies like India does.

²⁰ Standard & Poor's 2015.

²¹ The fiscal year in India starts in April and runs through March of the following year.

²² IMF 3/2/16 Country Report No. 16/75.

²³ GOI Economic Survey 2014-15.

²⁴ Ibid.

²⁵ Information from IMF and/or Government of India Budget Explanation.

²⁶ Ibid.

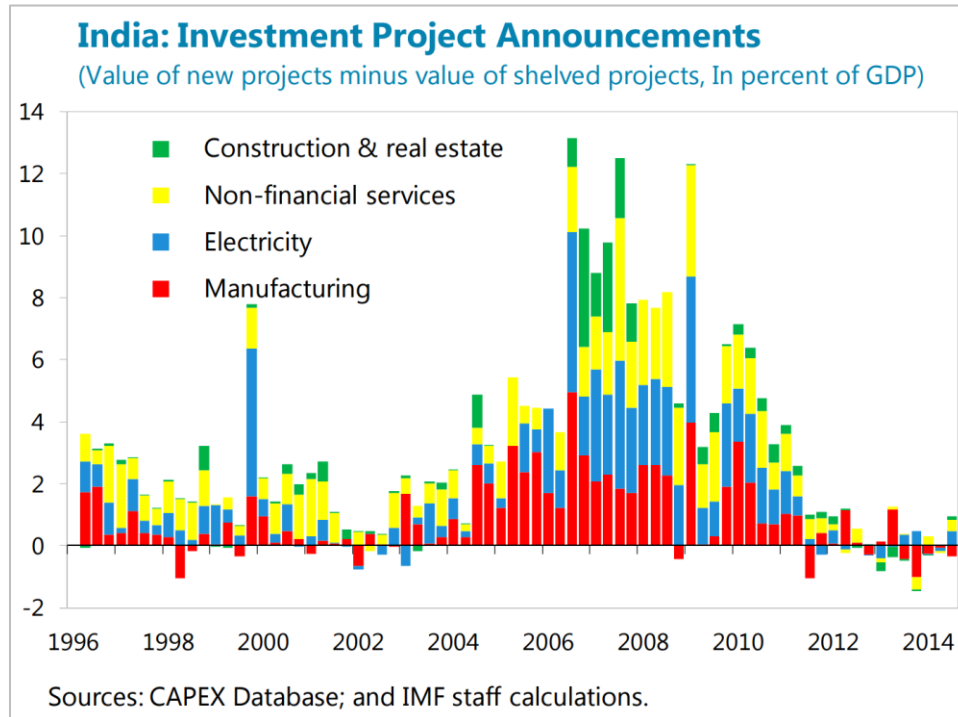
²⁷ Ibid.

²⁸ Ibid.



The stalling rate began to plateau in 2014-15 and the inventory of stalled projects decreased slightly. Due to the limitations on government investment, private investment remains the primary engine of long-term growth.

Figure 8 – Public and Private Investment in India’s Key Sectors



Source: IMF country Report 15/62, page 56, March 2015

India’s Corporate Sector

A private sector “asset bubble” is not inconsistent with the data. Some analysts think that Indian private corporations face a classic debt overhang problem in the aftermath of a debt-fueled investment bubble, further exacerbated by difficulties in devising an exit strategy from poor projects. India has weak institutions relating to bankruptcy (Debt Recovery Tribunals, Asset Restructuring Companies) which makes exit procedures from poor projects inefficient and time consuming. The Modi government has implemented some measures to streamline resolution of insolvent projects.

Corporate leverage in India is about 150 (debt-to-equity), among the highest in emerging markets. The top one percent of companies in India account for half of the overall debt. Infrastructure sector, including electric power, gas and water, accounts for 35% of corporate debt.²⁹ The gas, water and electricity sector has the second highest debt-to-equity ratio at an average of about 150, following the construction sector at an average of about 225 (Figure 9).

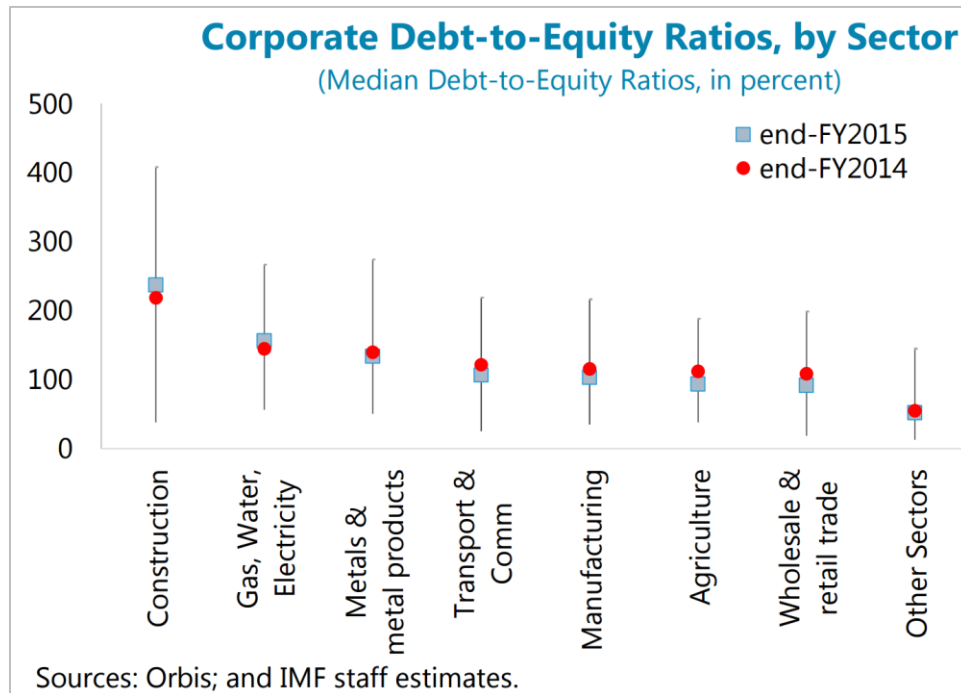
The Modi government has enacted many positive reforms including improved governance of public sector banks; an Rs 200 billion fund for infrastructure; new bankruptcy and debt restructuring procedures; a 5% corporate tax decrease; subsidy rationalization; a revised coal mine leasing process; liberalization of foreign direct investment policy; an urban development initiative and a scheme to

²⁹ IMF Country Report No. 16/76, March 2016.



financially restructure debt-laden state-owned power distribution companies, among others. However, to date the government has not succeeded in obtaining key legislation addressing the goods and services tax (GST) and a more industry-favorable land acquisition policy and its overall reform implementation capacity is uncertain. Both the GST and the land acquisition legislation are perceived as critical to India’s further economic progress and setbacks in these areas have helped tilt overall economic risks to the downside.³⁰

Figure 9 – Health of the Indian Corporations



Source: IMF country Report 16/76, page 7, March 2016

Due to the limitations on government investment, private investment remains the primary engine of long-term growth. However, the pace and strength of private sector investment recovery is uncertain as is the outlook for natural gas demand growth in the manufacturing sector. Key developments to monitor include:

1. the pace and magnitude of private and public sector investment, particularly those that affect energy intensive industries;
2. further implementation of subsidy reforms that free up public capital;
3. the passage of the GST and land acquisition legislation together with additional labor market reforms;
4. the inventory of stalled projects and the pace of stalling and resolution;
5. private sector profitability and debt levels; and
6. the pace and magnitude of electric distribution companies restructuring.

³⁰ Modi’s BJP party does not control the upper house of Parliament and the opposition has been able to block the proposed GST and land acquisition legislation.



NATURAL GAS MARKET CHARACTERISTICS

China's natural gas market is about four times the size of India's: 197 BCM versus 51 BCM in 2015. Contributing to the size differential between the Chinese and Indian natural gas markets are significant differences in the size, integration and geographical reach of their gas infrastructure. Development of the natural gas resource base, gas import capacity and the associated gas delivery infrastructure is significantly more advanced in China than India (Table 3). China's domestic gas production has increased more rapidly than India's growing at an average annual rate of 11% 2005-2015 compared to less than 1% in India over the same period. As a result, India's reliance on imports as a percentage of total gas supplies was 43% in 2015 compared to 30% in China.

Despite its larger size, China's gas infrastructure is not well integrated and is concentrated in four areas around Beijing and Bohai Bay, Shanghai and the Yangtze River delta and central west Chongqing. There are regional and local gaps, especially in the northeast and growing southeastern coastal areas as well as lack of delivery capacity between some gas import terminals and demand centers. China has a growing space heating market in the northern parts of the country but lacks the gas storage capacity necessary to manage seasonal swings in demand. China's gas infrastructure may not have the flexibility needed to perform peaking and other load balancing services for the power industry.

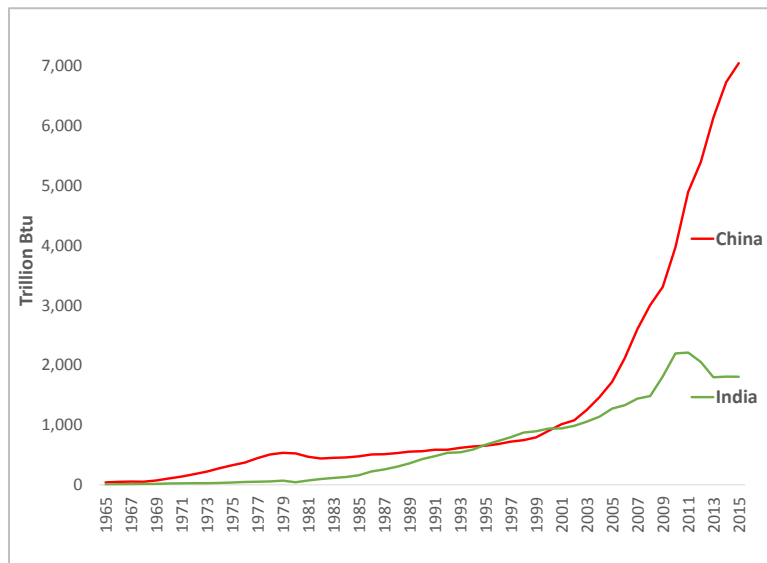
India's gas infrastructure is much less extensive and more highly fragmented than China's. India's domestic gas production has been declining since 2012 in part due to lack of investment in the upstream sector which in turn is partly due to a government administered natural gas pricing system that does not incentivize upstream investment. 40% of India's gas pipeline and distribution infrastructure is only in the two western states of Gujarat and Maharashtra. It is difficult to extend the gas delivery infrastructure in India and/or build new import terminals due to limited capital markets and significant land acquisition problems as well as the myriad of problems afflicting the expansion of any industrial activity in India.

Historical Trends in Natural Gas Consumption

Neither country was a major consumer of natural gas until the early 2000s (Figure 10). However, Chinese consumption of natural gas started to grow exponentially in the early 2000s. Between 2009 and 2010, growth was 20.1% with additional growth of 23.3% between 2010 and 2011. Between 1999 and 2011, average annual growth rate was more than 16%, outpacing GDP growth of about 10%. This growth slowed down significantly in recent years, to 4.7% from 2014 to 2015, still faster than the growth in primary energy demand at about 1%. It is noteworthy that the service sector's contribution to GDP (45.5%) surpassed that of industry (45%) for the first time in 2015.

Despite the recent slowdown in gas demand growth, average annual growth between 1999 and 2015 was still close to 15%. In contrast, coal demand grew by about 5% per year on average over the same period. As a result of this growth, China accounted for 5.7% of global gas consumption in 2015 as compared to 4.2% in 2011 and 1% in 2000. The primary drivers of gas demand growth were the large expansions in manufacturing and power sector gas demand, which grew at 16% and 22%, respectively between 2005 and 2015. The growth of natural gas consumption in China has been supported by the expansion of import projects such as long-distance pipelines from Central Asia and Myanmar, and LNG import terminals.

Figure 10. Natural Gas Consumption in China and India

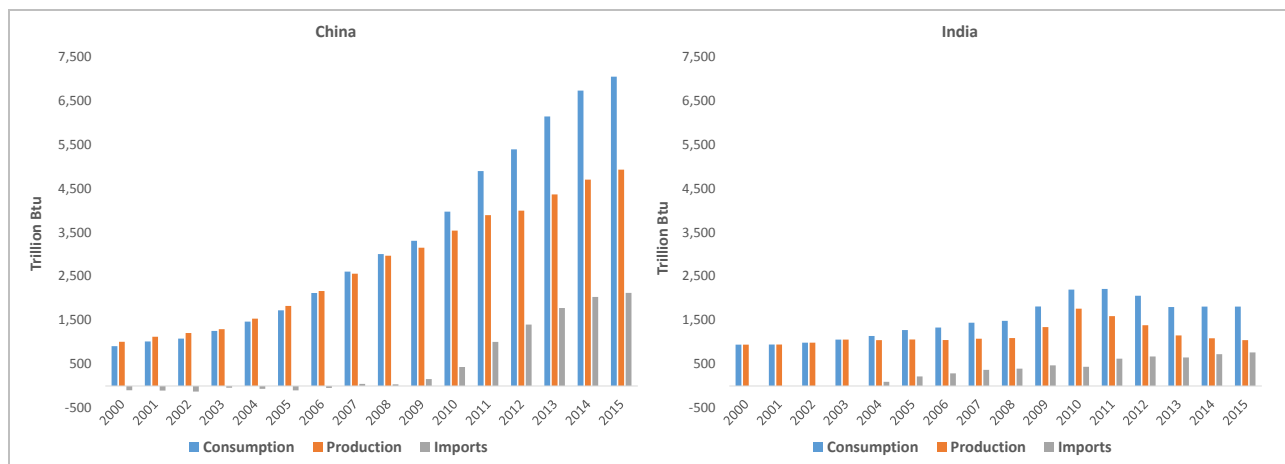


Source: BP Statistical Review of World Energy 2016

Natural gas consumption in India grew fairly consistently between the early 1980s and 2008 at an average annual rate of 11%. The growth in 2009 and 2010 was very high at more than 20% each year but there was no growth in 2011 and consumption contracted by 7% in 2012 and 12.5% in 2013 and remained flat since then. As a result, India consumes only 1.5% of global natural gas.

Beginning in 2012 natural gas demand growth fell below that of both total energy demand growth and GDP growth. This decline is only partially a result of weaker demand: it is also due to supply constraints, particularly a rapid decline in lower-priced domestically produced gas and bottlenecks in the gas infrastructure. India did import volumes of LNG to partially offset the domestic gas shortfall over this period but until recently it was simply too expensive for some end-users, especially in power generation and fertilizers.

Figure 11 – Natural Gas Production, Consumption and Imports in China and India, 2005-2015

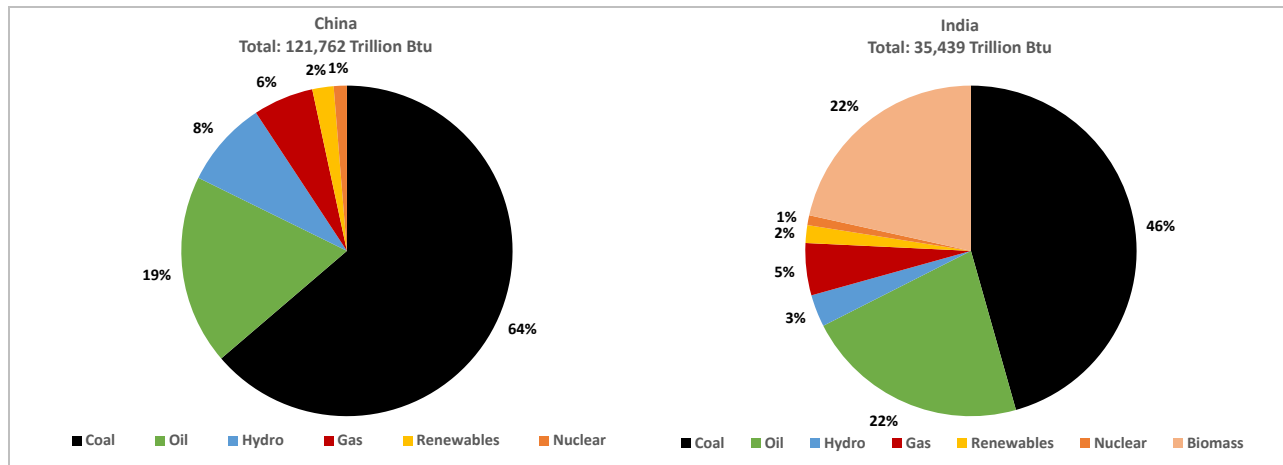


Source: BP Statistical Review 2016

Role of Natural Gas in Total Primary Energy

Both countries are heavily dependent on coal and oil despite years of policies to promote natural gas, renewables and nuclear (Figure 12). India is also heavily dependent on non-commercial biomass (estimated at 21% on the basis of IEA’s World Energy Outlook 2015). In 2015, coal accounted for 64% of total primary energy consumption in China and 46% in India (58% of commercial energy). Oil was in second place in both countries with 19% in China and 22% in India (28% of commercial energy). It is highly likely that heavy subsidies, especially in India, inflated the role of oil and coal in both countries. Still the transition is taking place; natural gas accounted for almost 6% of China’s total primary energy consumption in 2015 up from 2% in 2005 whereas coal’s share declined from 72% to 64%. Reasons for the declining share of coal include replacement of old coal fired generation plants with more efficient supercritical technology and policies mandating the reduction of coal use in industrial applications.³¹

Figure 12. Distribution of Primary Energy in China and India, 2015



Note: About one-third of the Chinese population have no clean cooking facilities and use coal and biomass. The NBSC does not include biomass in its primary energy reporting. IEA estimated china “bioenergy” at 216 MTOE in 2013 or 7% of total primary energy demand (TPED). In India, IEA says bioenergy is 188 MTOE in 2013 or 24% of TPED.³² Source: BP Statistical Review of World Energy 2016, CEE estimates for biomass in India based on IEA WEO 2015.

In India, the share of natural gas in total primary energy mix has not changed significantly since 2000. Coal’s share of primary energy demand has grown due to expansion of the coal-fired power generation fleet and increased use of coking coal in the steel industry. The use of biomass has declined as other fuels, principally LPG and, to a lesser extent, natural gas is used for cooking.

Natural Gas Supplies

Although China and India have locations where natural gas resources could be exploited, neither one has an endowment large enough to support potential demand (should gas truly make incursions into applications and segments dominated by other fuels). Thus, both countries are faced with importing

³¹ Per the IEA, China has contributed most to the global increase in coal power plant efficiency as it built numerous advanced coal plants while retiring inefficient plants. China’s coal-fired plant efficiency is now equal to that of OECD countries. (IEA, WEO 2015).

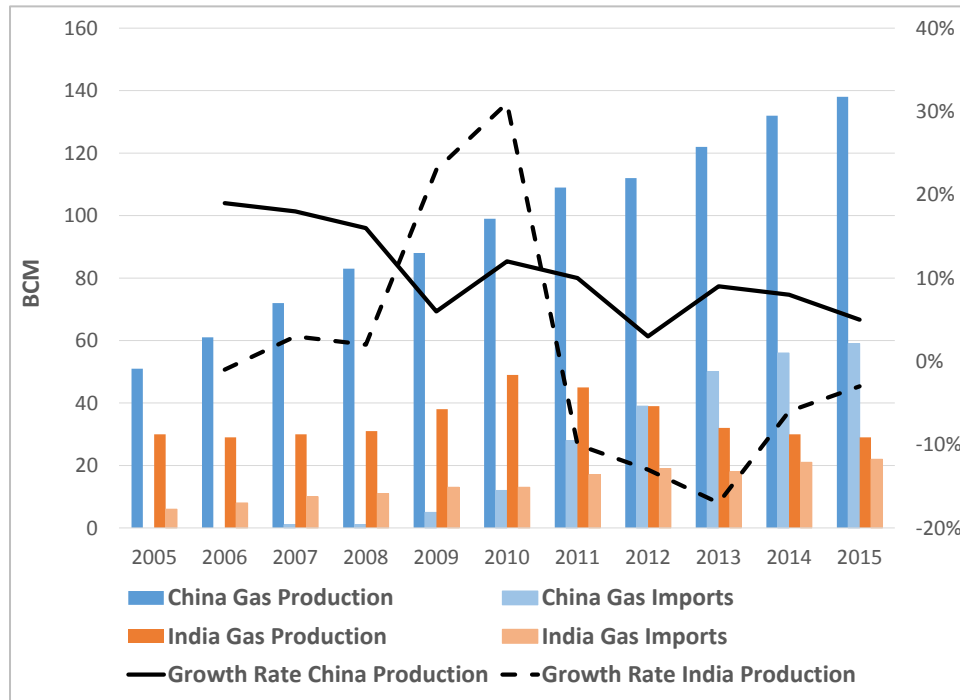
³² IEA WEO 2015.



enough quantities of natural gas to satisfy customer requirements. Both pipeline and LNG import deliveries are challenged by infrastructure, costs and myriad inadequacies in forming internal gas price signals. Maps of gas basins, where some production is located, demand centers and infrastructure are provided in Figure 45 and Figure 47 in APPENDIX 1.

China’s gas production grew at an average annual rate of 13.5% during 2005-2015 compared to a 15% growth rate in gas demand over the same period. In contrast, India’s gas production grew less than 1% 2005-2015 compared to a 4% growth rate in demand.

Figure 13. China and India Gas Production (BCM), Gas Imports (BCM) and Production Growth Rates %



Source: BP SR 2016. Growth rates are annual averages.

Table 2. Snapshot of China and India Natural Gas Supplies

Indicator	China	India
2015 Proved Gas Reserves TCM	3.8	1.5
2015 Gas Production BCM	138	29
2015 Gas Imports BCM/ Percent of Total Gas Supply	59/30%	22/43%
Percent Pipeline	58%	0%
Percent LNG	42%	100%

Source: BP SR 2016

Gas production in China is dominated by its three state-owned national oil companies: PetroChina, Sinopec and CNOOC. PetroChina controlled 68% of 2014 gas production, followed by Sinopec (16%) and CNOOC (11%).³³

³³ Energy Insights, McKinsey, 2016.



The Ordos basin is China's largest gas producing region accounting for 31% of total gas production in 2014.³⁴ State-owned PetroChina, together with some international oil company partners, are beginning to exploit the largest fields' tight gas resources which could possibly add 30 BCM of new production. PetroChina's Tarim field is the second largest gas producer in the country accounting for 18% of 2014 production. It was developed in 1989 and reached peak production in 1989; PetroChina thinks it has undiscovered resources in the field.

The Sichuan basin has two high-sulphur gas fields operated by state-owned Sinopec one of which peaked in 2012 and the other began production in 2014. Offshore gas production is led by state-owned CNOOC and its large gas field in the western South China Sea which has been declining. CNOOC expects a pipeline of exploration and production projects to contribute to increased gas production post-2018.

China's shale gas resources are estimated to be the largest in the world but production to date has been disappointing due to difficult geological and topographical conditions, relatively high costs and insufficient pipeline infrastructure, among others.³⁵ There are wide-ranging forecasts of possible shale gas production in 2020 of 15-30 BCM.³⁶

The forecasts we reviewed have wide-ranging estimates of future Chinese natural gas production by 2030 from 160-400 BCM due to differing views on potential shale gas, tight gas and coal bed methane production. Given the uncertainties surrounding China's unconventional gas resources, our view is closer to the lower end of the forecasts.

The bulk – some 75% – of India's proved natural gas reserves are offshore and slightly more than half of these offshore reserves were controlled by state-owned ONGC. State-owned OIL and ONGC control 92% of India's onshore proved gas reserves.³⁷ In 2004 a large gas discovery in India's eastern offshore region, Krishna-Godavari (KG) D6, was made by BP and Reliance Industries. Production from KG D6 began in 2009, peaked in 2010 and began to decline at a faster than expected rate thereafter accounting for most of the decline in India's gas production 2005-2015. Analysts believe that up to 10 BCM in production could be restored at the KG D6 fields with additional development expenditures. However, the KG D6 partners have been unwilling to make the capital investment to date due to an ongoing price dispute with the government.³⁸

The Krishna Godavari basin offers the highest prospect for gas production growth according to BMI Research. Deepwater KG development requires prices of around \$7.15/MMBtu compared to today's \$3.15/MMBtu.³⁹ Indian producers have been saying for several years that gas prices of \$6.00-\$7.00/MMBtu are necessary to revive gas production, with most of the new production coming post-2020.⁴⁰ BMI thinks that higher prices would unlock a number of shale gas and coal bed methane projects that have been difficult to get off the ground.⁴¹

³⁴ BMI Research, 2016, China Oil & Gas Report Q4 2016.

³⁵ Energy Insights, McKinsey, 2016.

³⁶ Ibid.

³⁷ GOI Vision 2030.

³⁸ BMI Research, 2016, India Oil & Gas Report Q4 2016.

³⁹ Ibid.

⁴⁰ Sen, A., 2015 and GOI Vision 2030.

⁴¹ BMI Research, 2016, India Oil & Gas Report Q4 2016.

The forecasts we reviewed either expect continued declines in domestic gas production through 2025 from 38 BCM to 27 BCM or increases from 38 BCM in 2014 to 40-63 BCM in 2030. Our view is closer to the less aggressive scenarios given the lack of upstream incentives in the current pricing mechanisms, the slow pace of upstream energy reform and the difficult struggle to increase production at KG D6.

Natural Gas Infrastructure

A well-connected and pervasive gas transport network with sufficient storage capacity (preferably large underground storage with good geographic diversity) to handle seasonal and daily demand variations are necessary for a robust natural gas market. Both countries, India especially, need significant future infrastructure investment in order to meet the natural gas demand envisioned in many forecasts. The constrained availability of funding for gas infrastructure in India is a serious impediment. Not only is the required investment level daunting but additional issues such as community opposition, geographical challenges and environmental obstacles can negatively impact both timing and ultimate cost. This “network requirement” for natural gas can disadvantage it against competing energy sources that either do not require such a high degree of transport and storage infrastructure or have it already.

China’s gas infrastructure is not well-integrated. Numerous regional pipeline bottlenecks exist, distribution is inadequate in some places and the country has insufficient storage for⁴² and many bottlenecks in moving regasified LNG from import terminals to demand centers. However, further gas pipeline and storage development is required to (1) expand natural gas deliveries to new and/or underserved demand centers; (2) to expand CGD networks in more cities and to integrate regional and local CGD networks with LNG regasification terminals and the national trunk lines, and (3) possibly to accommodate future gas deliveries from Russia’s Siberian gas fields in 2018. China has plans to double the size of its pipeline network by 2020 but it is not certain that they will do that given the current economic situation. Its state-owned oil and gas companies, especially PetroChina, are under severe financial pressures from imported gas losses, the low crude oil price and the November 2015 gas price reduction.

India is at an earlier stage than China in the development of its natural gas infrastructure and has a long way to go to the establishment of a National Gas Grid. The government recognizes that reforms are needed in the areas of gas pricing, pipeline regulation and tariffs and overall market design. A more favorable land acquisition regime is critical. Currently the consent of 70-80% of families affected by a project requiring land use must be obtained.

Funding of infrastructure investment is a big challenge in India. There are competing claims on public funds as well as an overall fiscal constraint resulting in low public investment levels. Greater private investment, including foreign investment, is required and to date has not been forthcoming in large quantities. In the natural gas sector, there are many factors that curb the appetite of private investors including administered pricing for natural gas and electricity; near-bankruptcy of many electric distribution companies; a complex and administratively difficult business environment; economic reform delays; regulatory conflicts; blurred authority boundaries among local, state and central governments and environmental and community opposition. In addition, there are not many financing options for private investors: currently Indian banks, many of which have large stressed loan portfolios, provide 90%

⁴² China has 129 operational domestic liquefaction plants with an annual capacity of 32 BCM/year. In March 2016, these plants were operating at 40% of capacity. Most of this domestic LNG is delivered by truck.



of corporate financing on a short term basis. The longer term corporate bond market is under-developed although the government is taking steps to improve the situation. Foreign direct investment flows are improving but are small relative to the infrastructure needs. The IEA in 2015 said that the scale of required energy sector investment and the high levels of uncertainty surrounding funding sources presented a downside risk to their consumption projections.

China

The backbone west-to-east national trunk pipeline system connecting western domestic gas supplies and imported Central Asian gas supplies to demand centers in eastern coastal regions is fairly well-developed due to accelerated investment by PetroChina (Figure 45). There are three west-to-east pipelines constructed since 2002 with the third put into operation in 2015 with a combined capacity of about 2.8 TCF/year (EIA, 2015). PetroChina controls about 80% of China’s gas pipelines and is China’s largest gas producer (3 TCF in 2014).

State-owned Sinopec operates key long-haul pipelines that connect central domestic gas supplies in Shaanxi and Sichuan to Shanghai in the south and to Shandong along the northeastern coast. In 2016 Sinopec announced it would sell 50% of the \$9.4 billion Sichuan-Shanghai pipeline to fund new projects in shale gas extraction.⁴³ Offshore pipelines off the eastern and southern coasts owned by state-owned CNOOC connects offshore gas supplies with demand centers.

Table 3. Natural Major Gas Pipelines in China

Pipeline	Origin	Destination	Transmission Capacity (Bcm/yr)	Remarks
Shale Gas Pipeline	Changning Shale Block, Sichuan	Yunnan	1.64	92.8 km
West-East (First Pipeline)	Xinjiang	Shanghai	12	Active since 2004
West-East (Second Pipeline)	Turkmenistan Xinjiang	14 provinces, autonomous regions, municipalities to the Pearl River Delta	30	Active since 2011 8,700 km Expansion began in March 2012 to connect pipeline to Hong Kong
West-East (Third Pipeline)	Xinjiang	Fuzhou, Fujian	30	Will be linked to the Central Asia pipeline, which brings in gas from Turkmenistan and Uzbekistan 817 km segment connecting Jiangxi-Fuzhou will be completed in H215
Central Asia-China Gas Pipeline	Turkmenistan Uzbekistan Kazakhstan	Xinjiang	30 Will be expanded to 55 Bcm/yr in H215	Active since 2009 (Line A), 2010 (Line B) and 2014 (Line C)

⁴³ Yu, F., 2016.



Pipeline	Origin	Destination	Transmission Capacity (Bcm/yr)	Remarks
Sichuan-East China Gas Pipeline	Sichuan	East China	12	Active since 2010 1,674 km
Myanmar-China Gas Pipeline	Kyaukryu Port, Myanmar	Yunnan, Guizhou, Chongqing, Guangxi	12	Active since 2014 2,806 km
Russia-China Gas pipeline (Power of Siberia)	East Siberia, Russia	North East China	-	Expected in 2019 3,968 km
Altai Gas Pipeline	West Siberia, Russia	North China	30-85	Proposed 2,800 km
Qinshul Basin Pipeline (CBM)	Qinshul Basin, Shanxi	West-East Pipeline	3	Active Since 2009 35 km

Source: BMI Research, 2016, June, China Oil & Gas Report Q3.

Pipeline Imports

In addition, China has two international gas pipelines used to import natural gas from Central Asia (Turkmenistan, Uzbekistan and Kazakhstan) and offshore gas from Myanmar. The Central Asian Gas Pipeline (CAGP), which has delivery points in western China, began operation in 2010 and has been rapidly expanded to its current capacity of 1.9 TCF/year (EIA, 2015). CAGP capacity utilization was about 55% in 2014. Another capacity expansion of 880 BCF/year is expected to be complete in 2016. The 420 BCF/year China-Myanmar pipeline has delivery points in southern China and began operations in 2013. 2014 capacity utilization was about 28% (EIA, 2015). Gas supplies for the Myanmar-China pipeline are dependent on further development of Myanmar offshore gas fields.

The 1.3 TCF/year proposed Power of Siberia pipeline will connect Russia's eastern Siberian gas fields to delivery points in northeastern China. Construction on the Chinese section of the pipeline began in mid-2015 and on the Russian section in 2014. The pipeline is projected to be operational in 2018. However, as of January 2016 reports say that only 50 miles of pipeline have been built (Lelyveld, 2016a). China insisted that priority be given to the eastern route in order to relieve air pollution problems in the industrial northeast. However, the industrial northeast has the lowest GDP growth in the country and has massive industrial overcapacity. An expected \$25 billion prepayment from the Chinese to Gazprom never materialized and there is little pressure for speed on the Chinese side. It has been reported that some analysts do not expect significant gas volumes to flow until 2025 or beyond (Lelyveld, 2016a).

The 1.1 TCF/year Power of Siberia-2 pipeline that would deliver Russian gas to western China and its shorter, less expensive route is preferred by Russia. Unlike the first Power of Siberia pipeline, there is no final supply agreement between the two countries for Power of Siberia-2 and its future is even less certain than that of the first pipeline (Lelyveld, 2015a).



Despite the rapid progress in developing import gas pipeline infrastructure,⁴⁴ the IEA in 2012 stated that China's pipeline network is insufficient when compared to its annual demand levels.⁴⁵ Additional long distance high pressure pipelines and the development of regional networks are required. China's pipeline network is not yet expansive enough: it connects certain gas producing areas with certain demand centers but its ability to deliver gas to southern areas is constrained.⁴⁶ Many regional networks and storage capacity need additional development.

China has about 7.4 Bcm of working gas storage capacity,⁴⁷ even though it has depleted gas reservoirs that could be used for this purpose. With the exception of a single facility in Xinjiang, all the remaining storage is in the high heating demand northeast CNPC, the parent company of PetroChina, is the major gas storage developer. The government wants storage capacity sufficient for 30 days of consumption. If all projects in construction and planning phases are developed, capacity could approach 47 Bcm with about 50% located in Beijing, Tianjin and Hebei.⁴⁸

In addition, city gas distribution companies have cryogenic LNG tank storage associated with domestic liquefaction capacity of 32 Bcm/year at the end of 2015 (see APPENDIX 1 - MAPS).⁴⁹ City gas distribution companies cannot afford to develop underground storage capacity.

The lack of storage capacity is a concern in light of the growing residential gas market and the increase in gas-fired peaking generation. As a point of comparison, OECD European countries with a high gas import dependency and a similar high share of residential demand have working storage of about 20% of their annual gas demand.⁵⁰ In the U.S., which consumes almost 23% of natural gas in the world as compared to 5.7% for China, there is 123 Bcm of natural gas storage capacity (or 60 times as much as in China), mostly underground in depleted reservoirs or salt domes. Each market is different in terms of composition of natural gas consumers, pipeline connectivity, geographic distribution of sources and consumers, and degree of seasonality but these comparisons indicate that China needs significantly more than the current level of storage capacity to have a smoothly-functioning natural gas sector without major dislocations and outages.

LNG Imports⁵¹

At the beginning of 2015 China had 12 LNG regasification terminals in operation with capacity of 5.2 Bcf/day with another 5 terminals under construction. 4.4 Bcf/day of additional capacity is expected to be on-line by 2017 (EIA, 2015). 10 Bcf/day of regasification capacity represents about 56% of China's

⁴⁴ An overview of Chinese pipeline infrastructure is provided in the separate Executive Summary.

<http://www.beg.utexas.edu/energyecon/GlobalGas-LNG/>.

⁴⁵ IEA, China Gas Pricing and Regulation, 2012. Germany, for example, has more than twice China's pipeline network but has lower annual gas demand.

⁴⁶ Overton, T.W., 3/4/13.

⁴⁷ BMI Research, China Oil & Gas Report, June 2016.

⁴⁸ BMI Research, China Oil & Gas Report, June 2016.

⁴⁹ BMI Research, China Oil & Gas Report, June 2016.

⁵⁰ Ibid.

⁵¹ A companion paper commissioned by CEE, *LNG Supply Outlook 2016 to 2030* by Andy Flower is available at <http://www.beg.utexas.edu/energyecon/GlobalGas-LNG/>. The reader should refer to that document for our consensus views on LNG supply and demand for China and India.



average daily gas consumption of 18 Bcf/day in 2015. Terminal capacity utilization was 59% in 2013, declining to 51% in 2014 (Russell, 2015).

Like major natural gas pipelines, LNG regasification terminals have been under the purview of China's state-owned oil and gas companies. CNOOC was the pioneer, followed by PetroChina in 2011 and Sinopec in 2014. CGD companies and/or local municipal governments have equity interests in six of the 12 operational terminals and in four of the 8 terminals under construction. CGD Jovo Group, serving southern markets, owns a 135 MMcf/D terminal at Dongguan. CGD companies have growing LNG businesses (see sectoral demand discussion) and find it easier to obtain terminal capacity for their cargoes when they have a terminal ownership interest. The NDRC issued guidelines in 2014 about allowing third-party access to existing terminals and as a result new players (such as CGD companies, private gas development companies and power generators), attracted by falling LNG prices, vie to contract for capacity in existing terminals. As of mid-2015 only PetroChina offered terminal import and storage services for a fee. CNOOC and Sinopec have been more reluctant saying that the guidelines are not laws (Xieli, 2015). Prolonged capacity negotiations with the terminal owner can derail opportunities for importing spot cargoes. Nevertheless, private companies like ENN Energy, one of the largest CGD companies, is constructing a 395 MMcf/D terminal in Zhejiang, which should begin operations in 2017. In March 2016 ENN signed a contract with Origin Energy to acquire 500,000 tonnes of LNG for five years beginning 2018/2019 from Origin's APLNG project in eastern Australia. ENN also signed a 10 year LNG supply contract with Total for 500,000 tonnes of LNG per year beginning in 2018.⁵² Guanghui Energy, a private gas development company, is building an 80 MMcf/D terminal in Jiangsu to come on-line late 2016. China Huadian, a large top five state-owned power generator, is seeking regulatory approval to build two new terminals and China Huaneng, another top five power generator, is planning to construct new terminals (Xieli, 2015).

CGD Networks

The city gas distribution networks have been rapidly expanded over the last decade. Numerous gas distribution companies were established over this period, many owned or associated with central and/or local government entities, which enabled an accelerated buildout of the networks. Annual sales volumes growth was 20% plus over this period, although growth rates have declined in recent years. Approximately 32% of medium and large-size cities (240 million people) in China had access to piped natural gas in 2014, leaving a large unserved potential market for CGD.

India

India's natural gas infrastructure (Figure 47) is fragmented and inadequate to move gas supplies to demand centers or to develop new demand centers. India currently has about 13,000 kilometers of gas transmission pipelines.⁵³ Total capacity of the onshore pipeline network was about 364 MMSCMD at March 2015, unchanged from the previous year.⁵⁴ State-owned GAIL India controlled about 63% of total operating natural gas pipeline capacity as of January, 2016 and 22% of capacity (the East-West Pipeline

⁵² BMI Research, 2016, June, China Oil & Gas Report Q3 June 2016.

⁵³ BMI Research, 2016, March, India Oil & Gas Report Q2.

⁵⁴ Offshore pipelines with capacity of 106 MMSCMD are owned by state-owned ONGC. Utilization was 43% in 2013-14 and 41% in 2014-15. Ministry of Petroleum and Natural Gas (MOPNG), 2014-15. Indian Petroleum and Natural Gas Statistics 2014-15; <http://www.petroleum.nic.in/docs/pngstat.pdf>.



from Andhra Pradesh to Gujarat; see maps in APPENDIX 1 - MAPS) was controlled by Reliance Gas Transportation Infrastructure Limited. The remaining 15% of capacity was owned by Gujarat State Petronet Limited, Gujarat Gas Company Limited, Indian Oil Corporation Limited, Assam Gas Company Limited, and Deepak Fertilizer & Petrochemicals Corp. Ltd.⁵⁵ Utilization of the onshore pipelines was 40% in 2013-14 and 2014-15.⁵⁶

There is a strong regional imbalance with regard to access to natural gas. 40% of India's gas infrastructure is concentrated in two western states: Gujarat (GJ) and Maharashtra (MH). Gujarat, Maharashtra and Uttar Pradesh (UP) together consume more than 65% of India's natural gas. Five states in the northeast have no pipeline infrastructure. The eastern, southern, central and northwestern regions have limited gas infrastructure.

To date India has been unable to create an expansive gas infrastructure across the country, in part due to lack of funding and difficulties in pipeline siting and land acquisition. The government has had a plan to spend \$8 billion beginning in 2012 to develop a National Gas Grid which would expand gas pipeline market delivery capacity to 515 MMSCMD by April 2017. Pursuant to this plan, the southern and northern states would catch up to the western states in terms of pipeline infrastructure. However, there has been practically no progress on this plan as the onshore pipeline capacity has remained flat at current levels since 2013. There are 11,300 km of pipelines reported to be under construction but only 100 km have been completed.⁵⁷ The lack of progress is attributed to legal disputes, land acquisition problems (see discussion of GAIL Kochi pipelines below), statutory clearances delays, contract issues and lack of anchor load customers (Oil & Gas Journal, 2015).

Gas Imports

India currently has four operational LNG regasification terminals on the west coast (Dahej, Hazira, Dabhol and Kochi, Figure 47) with a total import capacity of 23 million tons per annum (MMTPA). The largest of these, Dahej at 10 MMTPA, operates at a high load factor (96% in 2013-14) and an expansion to 15 MMTPA will be completed in 2016.⁵⁸ The Hazira terminal (5 MMTPA) operated at a 56% load factor in 2013-14. Equally-sized Dabhol terminal cannot operate during the monsoon season (May-October) in absence of a breakwater so its effective capacity is about half (2.25 MMTPA) of its nameplate capacity and its annual load factor is just less than 50% of 2.25 MMTPA. A breakwater is planned to be constructed in 2016.⁵⁹ Another 5-MMTPA terminal at Kochi operates at less than 2% load factor because GAIL has been unable to complete new pipelines to northern Kerala, Mangalore and Bangalore. The terminal is sending out small volumes of LNG by truck. GAIL had to suspend pipeline construction work in 2013 due to farmers' protests that grew into a large political issue in the state of Tamil Nadu illustrating the difficulties of land acquisition for non-agricultural purposes.⁶⁰ The four

⁵⁵ Petroleum and Natural Gas Regulatory Board, Data Bank, Operating Natural Gas Pipelines in India, 2016.

⁵⁶ Ministry of Petroleum and Natural Gas (MOPNG), 2014-15. Ministry of Petroleum and Natural Gas (MOPNG), 2014-15. Indian Petroleum and Natural Gas Statistics 2014-15; <http://www.petroleum.nic.in/docs/pngstat.pdf>.

⁵⁷ MOPNG, Petroleum Planning and Analysis Cell, Gas Pipeline Construction.

⁵⁸ Petronet LNG Ltd., October 2015.

⁵⁹ *The Economic Times*, 5/3/15.

⁶⁰ The Supreme Court of India in early 2016 ruled against the Tamil Nadu's government's petition to re-route the pipeline and instructed GAIL to pay enhanced compensation to the farmers. GAIL started the project in 2012 but

terminals together had load factors of 70% and 77% for the first ten months of 2014-15 and 2015-16, respectively.

There are seven planned LNG import terminals, with five of them on the east coastline of India. However, the only that has been making progress is the terminal proposed for the Gujarat state on the west coast. Given the limitations of pipeline infrastructure on the eastern states (with the exception of the Kakinada location), it is difficult to see how these other projects can proceed.

The Asian Development Bank is sponsoring the 1,600 kilometers Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline which would transport 33 BCM/year from Turkmenistan to the other three countries. In April 2016 the TAPI shareholders signed an Investment Agreement to provide over \$200 million to fund engineering and route surveys, environmental and social safeguards, and procurement and financing activities that will enable a final investment decision (FID).⁶¹ Once a positive FID is made, construction is expected to take up to 3 years. This project has been under development since 2003.

In October 2016 India and Russia announced an agreement to explore the feasibility of building a \$25 billion gas pipeline from Siberia to India.⁶² This project is in very early stages.

CGD Networks

The city gas distribution infrastructure mirrors that of the major pipelines infrastructure: the majority is in the states of Gujarat, Maharashtra, and Delhi in Uttar Pradesh with very limited or no coverage elsewhere (see APPENDIX 1 - MAPS)⁶³ Gas consumption by the CGD sector grew from 3 Bcm to about 5 Bcm in 2014. As of June 2015 there were 2.8 million consumers with access to piped natural gas. Future growth is constrained by the lack of infrastructure and gas supplies.

Gas Supply Allocation Policies

The central governments in both China and India direct natural gas supplies to certain sectors and prohibit or restrict its use in other sectors. India also uses price to discriminate among sectors: lower priced domestic gas is allocated to certain priority sectors and other sectors have to use more expensive imported LNG. These supply allocation policies can create demand distortions in the market.

China

China adopted a gas utilization policy in 2007 under the purview of the National Development and Reform Commission (NDRC). The 2007 policy permitted gas usage in the residential and industrial sectors, including natural gas vehicles (NGVs) but prohibited its usage for power generation with the exception of distributed combined heat and power (CHP). The policy was updated in 2012 and the prohibition on gas usage for power generation was partially lifted (Table 4).

the Tamil Nadu government stopped work in 2013 when 5,500 farmers protested. GAIL will have to re-tender the construction contract to re-start work.

⁶¹ Asian Development Bank, 2016.

⁶² *The Hindustan Times*, 2016.

⁶³ MOPNG, Petroleum Planning and Analysis Cell, September 2015.

Operationally the NDRC sets an annual natural gas production target based on customer consumption estimates submitted by natural gas producers.^{64,65} Actual gas production levels may deviate from the submitted targets as long as gas producers adhere to the NDRC’s annual natural gas guidance supply plan, which is based on the policy summarized in Table 4 and requires that specific gas volumes are delivered to designated key municipalities and key enterprises.⁶⁶ Residential gas consumers have first priority in a gas supply shortage situation (Li, 2015a).

Table 4. 2012 National Gas Utilization Policy in China by Customer Type

Type	Gas Consumers	Gas Supply	Gas Pricing	Gas Project Approvals
Preferred	Urban residential; public service facilities; NGVs and vessels; distributed CHP; storage facilities; interruptible industrial users	Priority assurance of supply except for interruptible industrial users	Preferential Discounted prices for interruptible industrial users	Preferential for projects displacing coal, oil and LPG
Permitted	Power generation; Chemical feedstock for low economic hydrogen & low economic nitrogen fertilizer	Priority after preferred		Peaking projects with sufficient gas supply
Restricted	Ammonia expansion; some chemicals using methane			Non-essential load power generation
Prohibited	Methanol production			Base load gas power in 13 large coal producing regions

Sources: Vinson & Elkins, 2013; Reuters; IEA 2009

India

India has an annual gas utilization plan that allocates the supplies of domestically produced natural gas and imported LNG to various customer classes (Table 5 below) and determines priority in a gas shortage situation. Since domestic gas has been much less expensive than LNG until recently, gas consumers have been anxious to maximize their allocation of domestic gas. (See pricing discussion). Fertilizer producers had the number one priority for many years until July, 2014 when they lost the top slot to city gas distribution (CGD) for households and transport. This change reflects the Modi government’s desire to significantly expand CGD throughout India. When he was governor of Gujarat state, PM Modi oversaw the establishment and expansion of very successful CGD operations which he would like to replicate nationally.

⁶⁴ State-owned PetroChina is the largest domestic gas producer and owns the vast majority of China’s onshore natural gas pipelines.

⁶⁵ PetroChina 2014 SEC Form 20F. About 78% of its sales volumes in 2014 were sold under one-year and multi-year contracts. Most of the one-year contracts have been renewed for 10 consecutive years. As a result, PetroChina is very familiar with its customers’ consumption patterns.

⁶⁶ PetroChina 2014 SEC Form 20F.



Table 5. Gas Utilization Policy in India (2013)

Tier	Customer and Priority Order	Domestic Gas %	LNG %
Tier 1	Fertilizer Plants; LPG Extraction Plants ; Grid-Connected Power Plants; City Gas for Households & Transport	86%	53%. Prices subsidized for fertilizer plants and grid connected power plants.
Tier 2	Steel, Refineries & Petrochemical Plants; City Gas for Industrial & Commercial Customers; Other Consumers, Captive & Merchant Power Plants, Feedstock or Fuel	10%	40%
Total		96%	93%

Source: Sen (2015a)

Fertilizer plants are still high priority along with grid-connected power plants and LPG extraction plants. The gas supply sources for Tier 1 customers were about 80%-84% domestic in 2013. Industrial customers (other than steel, refineries and petrochemical plants) and captive and merchant power plants are allocated the least domestic gas. This seems counter-intuitive as the industrial and merchant power sectors are highly price-sensitive and CGD household and transport customers are less so. In addition, end use prices charged by CGD operators are not controlled.

The Tier 2 customers' domestic gas supply was 33%-55% of their total gas supply depending on their place in the Tier 2 list. At times, Tier 1 customers may not be able to use all of their domestic gas allocation due to infrastructure constraints between the domestic gas source and the consumers' location. As a result Tier 1 consumers are allocated LNG as well. In 2013 Tier 1 users consumed over 50% of the total LNG supplied but it was subsidized for power and fertilizer plant users. Unused Tier 1 domestic gas allocations are then allocated to Tier 2 consumers.

As government, not market prices, determine resource allocation in India, consumption distortions can occur. For example, the fertilizer sector gets a very high percentage of its gas supply from cheaper domestic gas but even so its business is unsustainable without significant government subsidies. Gas-fired merchant power plants are allocated more expensive LNG to produce power that is too expensive for the almost bankrupt electric distribution companies to purchase. Further government subsidies are required in order to run those plants and avoid peak day electricity outages. Finally, a major competitor to natural gas, the subsidized LPG industry, is allocated less expensive domestic gas in order to reduce the government subsidy burden.

Regional Gas Consumption

Gas consumption in China and India is concentrated in certain regions which mirrors the gas infrastructure in each country. These regions include four areas around Beijing and Bohai Bay, Shanghai and the Yangtze River delta and central west Chongqing in China and the two western states of Gujrat and Maharashtra in India. These areas have been the focus of industrial activity, urbanization and population growth in the two countries to date. However, there are economic growth centers in areas of both countries which do not have sufficient gas infrastructure, especially the southeastern coastal areas of China and the entire southern region of India. India is undertaking a Smart Cities initiative which could accelerate urbanization and economic growth in areas that have little to no gas infrastructure at



present.⁶⁷ Significant expansion of gas infrastructure into these newer regions will be required to realize gas demand growth.

China

Natural gas consumption in China varies significantly by region (see map, Figure 45). It is influenced by a province's proximity to domestic gas production (Xinjiang, Sichuan and Shaanxi) and/or gas import infrastructure; its available gas infrastructure; its economic wealth and its industrial and power outputs. Four regions accounted for 60% of natural gas consumption in 2014: the southwest, the Bohai Bay area, the Yangtze River delta and the southeast coastal area. Additional CGD infrastructure and enhanced regional connectivity is required to increase market penetration across the rest of the country.

The gas producing regions are in the far west (Xinjiang), the northwest (Shaanxi) and the center-southwest (Sichuan). These provinces have China's top producing gas basins: Ordos in Shaanxi; Sichuan and Tarim in Xinjiang. They export gas (about 60% of local supplies) to nearby provinces like Chongqing and Henan and to the coastal provinces. Their infrastructure is more mature and their gas access rates are higher than the national average (57% and 45% for Sichuan and Shaanxi, respectively, by the end of 2012). Gas-fired power generation competes with hydropower in this area and can be significant in poor rainfall years. In Shaanxi the industrial sector is the major gas consumer whereas in Sichuan the residential sector dominates. These provinces also have the highest concentration of natural gas vehicles and fueling stations. The producing provinces and their neighbors enjoy natural gas prices that are among the lowest in the country as their gas supply is local.

Chongqing and Henan are not as industrialized as many of the coastal cities and provinces but their economies outgrew the national GDP growth rate of 7.4% in 2014: 11% and 9%, respectively. Henan had the fifth largest provincial GDP in the country in 2014 representing 5% of total GDP. Chongqing was among the top ten exporting provinces in 2014. Their neighboring provinces supply their gas and the natural gas prices in Chongqing and Henan are either below or at the national average.

The coastal provinces of Guangdong and Jiangsu and the metropolitan areas of Beijing and Shanghai are among China's wealthiest provinces/municipalities and are large natural gas consumers. The two coastal provinces represented 21% of the nation's GDP in 2014 and were the top two exporting provinces. They are heavily industrialized and Guangdong has significant gas-fired power generation (11.1 GW in 2014, which was about 17% of China's total gas-fired generation capacity). Power sector gas use accounted for 50% of Guangdong's total gas consumption in 2012, followed by industrial and residential gas use (30% and 11%, respectively). The low residential use was due to the lack of CGD infrastructure: the province's gas access rate was 16% compared to the national average of 34%. The regional grids in these provinces

⁶⁷ "Smart Cities" is an urban renewal and development program sponsored by the Modi government with the goal of redeveloping 500 cities and developing 100 new cities over five years beginning 2015-16 which will be equipped with basic core infrastructure and will offer a sustainable high quality of life to residents. 100 potential smart cities were nominated by the states/union territories and 20 cities (see map) were chosen in January 2016 from the list to receive financing. About 12 of the 20 cities are in areas with limited to no gas infrastructure. Ministry of Urban Development, Smart Cities: Mission Statement and Guidelines, June, 2015; The Hindu, 2016, January 30, Govt. announces list of first 20 smart cities under 'Smart Cities Mission', <http://www.thehindu.com/news/national/list-of-first-20-smart-cities-under-smart-cities-mission/article8162775.ece>.



have expanded rapidly but additional CGD capacity is needed. The majority of the gas supply in these areas is imported and they pay some of the highest natural gas prices in the country.

The capital district of Beijing has a gas consumption profile that is different from those of the large gas consuming coastal provinces. It has a services-oriented economy accounting for 78% of GDP in 2014. According to Li (2015b), about 65% of its gas demand in 2013 was for winter space heating purposes. There are significant seasonal and daily variations in gas demand: the ratio of daily peaking demand to lowest daily demand is consistently above 10. Gas use for power and heat accounted for 38% of total gas consumption in 2012 followed by 29% in the commercial sector and 13% in the residential sector. Beijing's gas consumption increased 13% in 2014 when nine gas-fired heat and power units (CHP) replaced coal-fired capacity and a colder winter followed a warm one in 2013.

To enable this increased gas demand, pipeline infrastructure was constructed to bring gas supplies from Shaanxi and the Tangshan LNG terminal to Beijing and its surrounding areas such as Tianjin, Shandong and Hebei. As a result, Beijing's gas consumption was expected to grow from 11 BCM in 2013 to 18 BCM in 2015. Natural gas prices in Beijing have been around the national average.

Future gas demand growth in the western producing provinces and their neighboring provinces depends on the increased industrialization and urbanization of these areas and continued expansion of the natural gas vehicles sector. In the coastal provinces, particularly in the south, gas demand growth will require significant expansion of CGD networks. Growth in coastal areas' gas demand for power generation requires lower LNG prices, which should be possible in the near term, and expansion of the regional infrastructure where necessary. In the Northern provinces, where coal dominates the space heating market, gas infrastructure construction, like that done for Beijing, will be required. Gas market development in low consumption provinces depends on the twin drivers of industrialization and urbanization and the construction of new gas infrastructure. Substantial increases in storage capacity will be necessary if gas is to play a significant role in power peak-shaving and weather-driven residential and commercial demand.

India

Many of India's current regional gas consumption issues are discussed in the section on infrastructure. This section will focus on India's future economic geography and the location of centers of potentially strong natural gas demand growth (see Figure 47 for general locations and patterns). Currently India's natural gas infrastructure is most concentrated in the current industrial regions of the west and northwest around Mumbai and Delhi. There is little to no gas infrastructure around Kolkata and the industrial regions in the east and south are underserved (Figure 47).

Going forward, there is a high probability that a significant part of India's future economic growth could take place in areas that currently lack adequate natural gas infrastructure. Continued growth in megacities like Mumbai and Bangalore is unsustainable. Instead India's focus is on the creation of smaller urban hubs all over the country that can negotiate infrastructure and basic services at the local level.

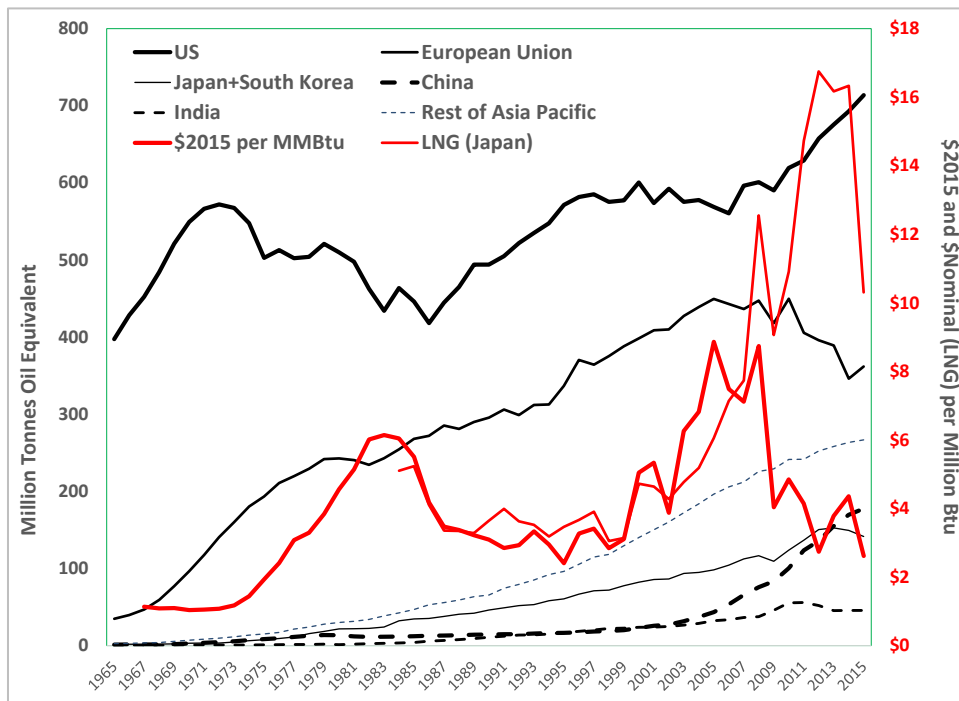
Natural Gas Pricing

In the bigger picture, gas buyers will tend to respond to lower prices especially if they are net importers. This has been the prevailing story for most of the world (Figure 14): for the U.S. since natural gas prices



collapsed in 2007 (new supply from drilling encountering recession and the warm 2011-2012 winter) and the Asia-Pacific region (where native growth in demand has been embellished by lower LNG prices, under pressure from both falling oil prices and generous feedstock gas and LNG supply and influenced by the U.S. Henry Hub marker). The exception has been Europe, where natural gas use diminished with economic deterioration on the continent and the resulting plight of Europe’s utility sector while also being impacted by rising oil-indexed LNG cost.

Figure 14. Global Trends in Natural Gas Prices and Demand



Source: CEE depiction based on BP Statistical Review data.

Natural gas demand in China and India is very price sensitive as all demand sectors have alternative fuel options. In both countries, natural gas prices are “administered” by both the central and local governments. The timing and magnitude of the government intervention is not always predictable, creating uncertainty for investors in all segments of the natural gas value chain. Markets do not play a significant role in pricing natural gas to various customers. The degree of market influence on the administered prices is a function of government political and policy goals as well as the price sensitivity and political influence of the consuming sectors. This price intervention by the governments in both China and India creates market distortions which in turn impede the development of a robust natural gas market.

China

Natural gas prices at the city gate are set by the NDRC (Table 6). The frequency of NDRC price adjustments is not defined; they have been more often since 2013. Provincial governments, through local pricing bureaus, establish the retail natural gas prices for end users. In April 2015 the NDRC set the

city gate natural gas price for industrial⁶⁸ and power generation users based on a formula using the prices of two substitutes: 85% of the weighted average of (60% of fuel oil import prices) and (40% of LPG import prices)).⁶⁹ The average city gate price was \$11.00/MMBtu in April 2015; there are significant regional variations (also see APPENDIX 1 - MAPS). Future price adjustments will be tied to that formula.

Table 6. China Natural Gas Prices as of March 2016 in US\$/MMBtu

	City Gate Non-Residential (Power & Mfg.)	Retail Power Generation	Retail Mfg.	Retail Transport (CNG)	Retail Residential Tier 1
Gas Producing Cities/Provinces (PP)& Neighboring Provinces (NP)/Cities (NC)					
Urumqi, Xinjiang PP	4.89		6.38-8.46	12.33	5.82
Xian, Shaanxi PP	5.70		10.46	15.77	8.42
Chengdu, Sichuan PP	7.01		13.73	12.75	8.03
Chongqing NC	6.93		9.10	13.90	7.31
Xining/Qinghai NP	5.40		7.69-9.27	7.40 (buses) 9.27 (other transport)	6.29
Lanzhou, Gansu NP	6.08		8.46	12.33	7.23
<i>Producing Areas Simple Average</i>	<i>6.00</i>		<i>9.19</i>	<i>11.96</i>	<i>7.18</i>
Gas Consuming Cities/Provinces					
Beijing Municipality	8.14	13.69	10.03-13.43	18.74	9.69
Shanghai Municipality	9.22	10.41	11.69 (chemical) 13.47 (city gas industrial)	20.32	12.75
Harbin/Heilongjiang	7.48		16.15	16.15	11.90
Nanjing/Jiangsu	9.22		13.22	17.85	10.63
Wujan/Hubei	8.33		14.85	17.43	10.75
Zhengzhou/Henan	8.54		12.33	15.56	9.56
Guangzhou/Guangdong	9.27		18.53	25.16	14.66
Hohhot, Inner Mongolia Autonomous Region	5.70		11.35	15.13	7.74
<i>Consuming Areas Simple Average</i>	<i>8.27</i>	<i>12.05</i>	<i>13.50</i>	<i>18.51</i>	<i>10.88</i>

Source: ICIS, China Gas Price Pool, China Gas Market Monthly, Vol.III-03, No. 18, March 2016.⁷⁰

Domestic natural gas producers are paid the city gate price less a pipeline transmission fee. Pipeline transmission tariffs are also determined by the NDRC based on construction and operating costs, distance from gas source to city gate, taxes and an “appropriate margin.” Tariffs also change according to the pipeline vintage. For example, tariffs are about \$4/MMBtu to Henan and \$5/MMBtu to Shanghai on the newer West-East pipelines (Table 7). The tariffs on older pipelines are lower. PetroChina reported

⁶⁸ All references to “industrial users” in the pricing discussion excludes fertilizer plants which have their own lower gas prices.

⁶⁹ Industry participants can charge up to 20% more than the NDRC-determined prices based on supply and demand. There is no downward limit on price fluctuations.

⁷⁰ ICIS sources its data from local pricing bureaus and local development and reform commissions. Reported prices in CNY converted to US\$ at rate of CNY6.49=US\$1. Reported prices per Kcm converted to MMBtu as follows: (US\$/Kcm/36.253)*100. www.icis.com/energy/channel-info-finder/.

an average tariff of \$.63/MMBtu in 2014.⁷¹ The distribution fees of CGD companies are set by provincial and/or local pricing authorities based on a cost analysis similar to that underlying pipeline tariffs.

Table 7. West-East Pipeline Transmission Tariffs in China

From Xinjian to:	Transmission Tariff (\$/MMBtu)
Gansu	1.3
Ningxia	1.6
Shaanxi	1.8
Shanxi	3.3
Henan	3.8
Anhui	4.2
Jiangsu	4.7
Zhejiang	4.8
Shanghai	4.9

Source: Paltsev and Zhang (2015).

In August 2016 the NDRC released a draft proposal reducing the return on gas pipeline investment from an estimated 10-12% to a cap of 8% based on 75% utilization rates with a goal of increasing transparency around pipeline operating costs; reducing city gate gas prices and eventually facilitating third-party pipeline access.⁷² Implementation will take time: pipeline cost estimates are not due for NDRC review until June 2017 with rate adjustments every three years thereafter. In addition, it is up to local governments whether or not to pass through any transportation rate decreases to end-users.

LNG importers and producers of shale gas, coal bed methane and coal gas are not governed by city gate prices and can directly negotiate prices with suppliers and buyers. Beginning April 2015 large industries and power producers were allowed to directly negotiate gas supplies and prices with domestic producers, pipelines and LNG importers. As a result, bypass of local gas distribution companies could occur.

Before April 2015⁷³ there were two city gate gas prices: a lower price for existing volumes (about 90% of volumes) and a higher price for incremental volumes (Figure 15, through mid-2015). This two-price regime was an attempt to reflect the higher prices of imported gas in the city gate prices. It was replaced by the formula linking city gate prices to the prices of alternate fuels in April 2015. The NDRC kept average city gate natural gas prices around the relatively high level of \$11.00/MMBtu as the prices of crude oil, LPG and fuel oil continued to drop and coal remained under \$5.00/MMBtu.

⁷¹ PetroChina SEC Form 20F 2014.

⁷² CNOOC claims that the pipeline rates of PetroChina and Sinopec are grossly inflated. PetroChina and Sinopec do not disclose their pipeline operating costs systematically. Guo, 2016; Meidan, 2016.

⁷³ The NDRC adjusted city gate natural gas prices three times between July 2013 and April 2015, resulting in a close to 40% increase over the period.



Figure 15. Prices for Oil, Imported LNG and Pipeline Gas, and City Gate Prices in China (\$/MMBtu)

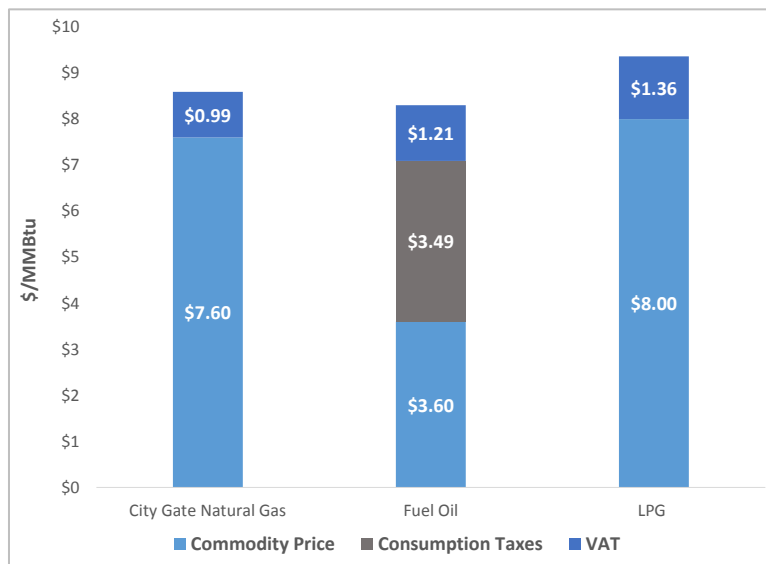


Source: Paltsev and Zhang (2015).

In November 2015 the NDRC lowered the average city gate price to \$7.60/MMBtu, reflecting the lower fuel oil and LPG prices. As a result, natural gas demand increased only 5% from 2014 to 2015, well below the 15% average annual growth rate of the last decade (previous Figure 14).

At the wholesale level (commodity price plus applicable taxes) natural gas became more competitive with fuel oil and LPG. Gas demand increased 9% from October to November 2015. As seen in Figure 16, fuel oil and LPG are taxed more heavily. Oil products consumption taxes have been raised in the last several years. Their VAT is 17% versus 13% for natural gas. There is no VAT on transport gas.⁷⁴

Figure 16. Estimated Wholesale Prices of Natural Gas, Fuel Oil, LPG in China March 2016 (\$/MMBtu)



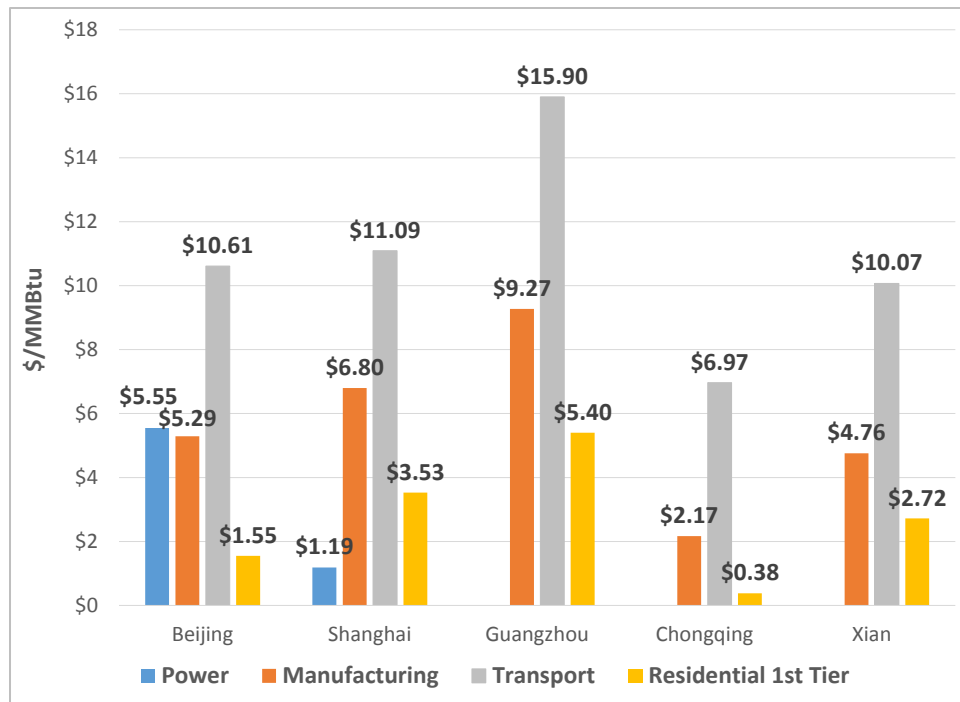
Source: CEE estimates

⁷⁴ PetroChina SEC Form 20F 2014.

CGD company bypass is possible for large non-residential users. However, China’s gas pipeline open access for third parties policy is in its infancy with the guidelines released by the National Energy Administration in February 2014 for “trial implementation” with the effective date of implementation unknown. PetroChina and Sinopec have had substantial discretion in determining whether or not they have surplus capacity and to date have not been required to “unbundle” transportation operations from their sales and marketing operations.⁷⁵ There were reports in 2015 that the NDRC was considering a plan to spin off SOE-owned pipelines into a separate company to ensure competitive access but PetroChina and Sinopec resisted strongly. That plan appears to have been abandoned and replaced by the August 2016 NDRC draft proposal reducing transportation costs. The August 2016 draft proposal states that pipeline owners should provide open access to infrastructure and that pipeline operations should be separated from other businesses or, at a minimum, be accounted for separately.

Distribution costs are a significant part of end-user prices. In Figure 28 the distribution gross margin, which includes distribution costs, taxes and cross-subsidies among sectors, is estimated by subtracting the city gate natural gas price from the delivered end user price. The higher gross margins for the manufacturing and transport sectors compensate for the lower margins on residential customers.

Figure 17. Distribution Gross Margin by City and Gas Consuming Sector March 2016 (\$/MMBtu)
(Delivered End User Price less City Gate Price=Gross Margin)



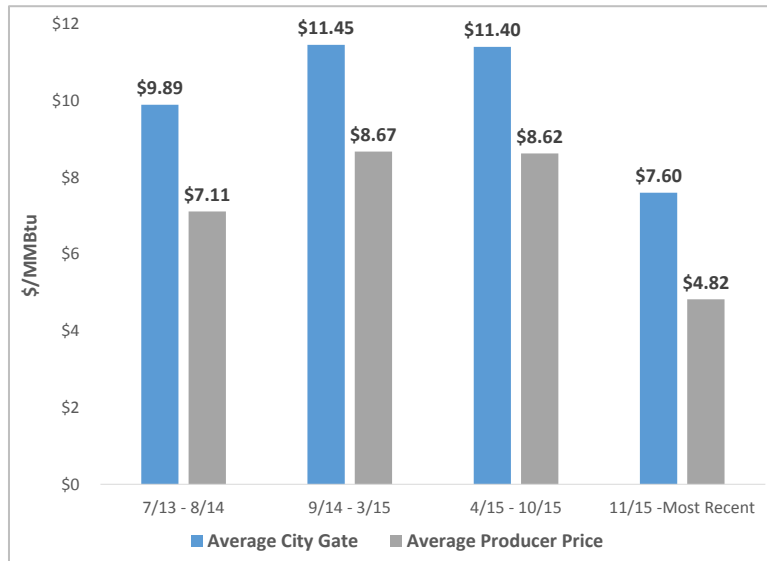
Source: ICIS, China Gas Price Pool, China Gas Market Monthly, Vol.III-03, No. 18, March 2016.
 Gross margin is CEE calculation.

The NDRC has a difficult balancing act. On the one hand, the government wants competitive natural gas prices to encourage consumption and on the other hand, it wants gas prices high enough to incentivize

⁷⁵ The two companies have often claimed that they are at full capacity in order to limit access and protect their midstream profits. Meidan, M., 2016, August 19, op.cit.

producer investment and to minimize the losses its national oil companies (PetroChina, CNOOC and Sinopec) are incurring on imported pipeline gas and LNG. It is reported (Lelyveld, 2016c) that some analysts think that the NDRC’s pricing policies have resulted in a “worst of both worlds” scenario: gas prices are too high to stimulate consumption and too low to incentivize production (Figure 18). Gas demand growth rates in 2014 (9.5%) and 2015 (4.7%) fell significantly below the double-digit growth rates of 2005-2013 (average 16.7%) as gas prices increased. On the other hand, domestic gas production grew at 9.3% and 7.7% in the higher price years of 2013 and 2014, dropping to 4.8% in 2015. PetroChina, the country’s largest gas producer, forecasts gas production growth of only 1.3% in 2016.⁷⁶

Figure 18. Average City-gate and Netback Producer Natural Gas Prices (\$/MMBtu)



Source: S. Paltsev and Zhang (2015) and CEE estimates for netback producer prices. The pipeline tariff used to estimate the netback producer prices is the simple average of the older pipeline tariff (\$0.63/MMBtu) and the newer high one to Shanghai (\$4.91/MMBtu).

In January 2016, the NDRC put a floor under LPG and fuel oil prices based on a crude oil price of \$40/barrel. If the crude oil price drops below \$40/barrel there will not be a corresponding decrease in LPG and fuel oil. This action suggests that the NDRC may prefer to maintain the prices of competing fuels at artificially higher levels rather than decrease natural gas prices further and impair upstream gas investment. The price floor is also meant to protect the refining profits of China’s state-owned oil and gas companies and to discourage “wasteful consumption.”

Residential, agricultural and fertilizer plant gas users did not experience the city gate price adjustments and the sector’s average retail rate has stayed around \$11.00/MMBtu. These sectors enjoy a cross-subsidy from the industrial, power and transport sectors. These cross-subsidies impair the competitiveness of natural gas in the major gas-consuming industrial and power sectors. As a result, many local and provincial governments commonly provide various subsidies to industrial and power gas users in order to generate provincial economic growth and protect provincial jobs (Haley and Haley, 2013). Tax incentives, cheap loans, credits for reducing air pollution and outright price discounts are some of the mechanisms deployed to keep industrial and power sector gas prices below the full

⁷⁶ Guo, 2016.

regulated rate. It is a common practice for gas-fired power generators to negotiate the gas price directly with local governments (Ng, 2015).

The continuing provision of sizable subsidies by debt-laden local governments to offset the costs of a growing cross-subsidy is probably not sustainable. Residential gas use grew rapidly over the past decade thereby increasing the cross-subsidy to unmanageable levels. The cross-subsidy needs to be eliminated to reduce the cost burden on the power, industrial and transport sectors and to stimulate demand in those large gas consuming sectors. However, residential rates are politically very sensitive and are administered by local government agencies. The agendas of local governments are not always consistent with those of the central government. In an effort to tackle the cross-subsidy, the NDRC in 2013 introduced tiered pricing (e.g., prices increase with volume used) for residential users in a six-city pilot program. Although the NDRC began to implement the pricing nationwide in 2015, it will not have a material impact in the near term because the lowest-priced tier, e.g., current residential rates, applies to about 80% of households. The second tier which has a 20% price increase from current levels applies to only about 15% of households. It is the beginning of a very long process.

The first six months of 2016 saw an initial sizeable demand response to lower domestic natural gas prices and lower imported LNG prices: gas consumption increased by 9.8% reaching 99.5 BCM in the first six months of 2016 compared with the same period in 2015 with LNG imports increasing 21.2% for the same period year on year.⁷⁷ However, domestic gas production increased only 2.9% over 2015 for the same six month period reflecting lower prices paid to producers.⁷⁸ Gas consumption growth moderated to 2.3% year on year July reflecting sluggish economic growth and weakening seasonal consumption.⁷⁹ LNG imports in July 2016 declined 17% from those in July 2015 as LNG prices into China increased. July 2016 pipeline imports, primarily from Turkmenistan and Uzbekistan, rose 21% from those in July 2015.⁸⁰ The average price of pipeline gas was \$4.77/MMBtu in July 2016 compared to \$5.40/MMBtu for LNG.⁸¹ Despite the fall in LNG and domestic gas prices in 2015 and the first half of 2016, coal-fired plants were still first in the dispatch order for baseload generation based on LNG prices into Guangdong in southern China.⁸²

India

Like China, India has administered pricing for natural gas: central and local governments intervene in price setting in all segments of the natural gas value chain (upstream, midstream and downstream end users). The Gas Utilization Policy (GUP) discussed previously (Table 5) determines end-user prices by sector. The GUP basically rations lower-priced domestic gas to Tier 1 priority sectors while LNG fills the remaining demand. Domestic gas prices are set by the central government; LNG prices are determined by contract and spot prices. However, if domestic gas supplies are not sufficient to meet 100% of Tier 1 demand and/or physical constraints impair the Tier 1 consumer's ability to take domestic gas, LNG is supplied to these customers at a subsidized price. Pooling of domestic and LNG gas prices is generally

⁷⁷ LNG World News, 2016.

⁷⁸ Kohl, 2016.

⁷⁹ China Daily, 2016. Bloomberg News, 2016, August 9.

⁸⁰ Sikorski and Tertzakian, 2016.

⁸¹ Ibid.

⁸² Ibid.

not permitted except for fertilizer plants and grid-connected power plants under specific pricing programs.

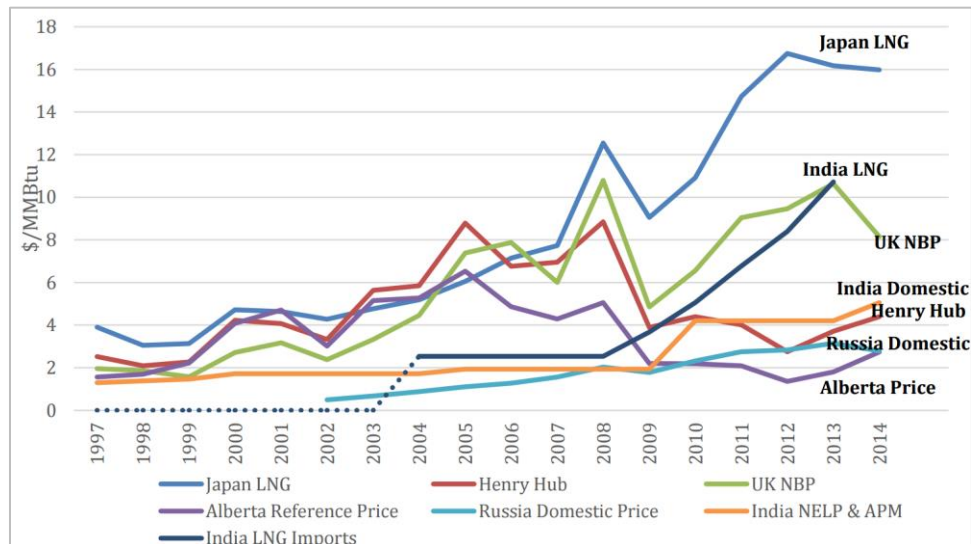
The pricing mechanism for domestic gas was revised in late 2014 in response to a continued decline in domestic gas production (a high of 53 BCM in 2010 to 19 BCM in 2014). Prior to that date, the gas price paid to producers stayed at or below \$2.00/MMBtu from 1997 to 2010 and was \$4.20/MMBtu from 2010 to November 2014. Concerned that prices were too low to spur upstream investment, the Modi administration tied the gas price paid to domestic producers to the gas consumption volume weighted average of natural gas prices in the U.S., Mexico, Russia and Canada:

$$\text{Domestic Natural Gas Price} = \frac{V_{HH} \cdot P_{HH} + V_{AC} \cdot P_{AC} + V_{NBP} \cdot P_{NBP} + V_R \cdot P_R}{V_{HH} + V_{AC} + V_{NBP} + V_R}$$

Where V_{HH} is total annual natural gas consumption in the U.S. and Mexico; P_{HH} is the annual average of daily prices at Henry Hub; V_{AC} is total annual natural gas consumption in Canada; P_{AC} is the annual average of monthly prices at Alberta Hub; V_{NBP} is total annual natural gas consumption in the EU and Former Soviet Republics excluding Russia; P_{NBP} is the annual average of daily prices at the National Balancing Point in the UK; V_R is total annual natural gas consumption in Russia; and P_R is the annual average of monthly prices in Russia. All prices include a deduction of \$0.50/MMBtu for transportation.⁸³

The new domestic pricing formula was highly controversial. Critics claimed that American, Canadian, European and Russian gas prices were not relevant to the Indian market and that the government was trying to manage the price level by selecting some of the lowest international gas prices (Figure 19). Domestic gas producers said they needed prices of at least \$6-\$7/MMBtu and sometimes \$10/MMBtu to revive domestic gas production.⁸⁴

Figure 19. Indian Domestic Gas Price versus International Gas Prices, 1997-2014 (\$/MMBtu)



Source: Sen (2015a).

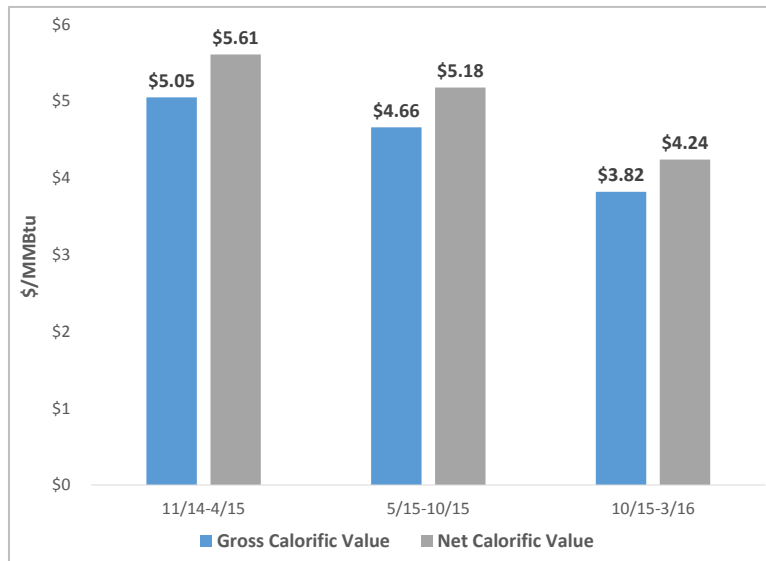
⁸³ Sen, A., April 2015.

⁸⁴ Sen (2015a). Ministry of Petroleum and Natural Gas (MOPNG).



Prices are reviewed every six months based on price and volume data for the previous four quarters with a one-quarter lag and are set based on gross calorific value. The resulting domestic gas price was \$5.05/MMBtu in terms of gross calorific value from November 2014 to April 2015.⁸⁵ Domestic price adjustments led the domestic gas price to decline to \$4.66 between May and October 2015 and \$3.82 since November 2015 (Figure 20). Underdeveloped states in the northeast receive a 60% discount on both domestic gas and LNG prices.

Figure 20. Indian Domestic Natural Gas Prices November 2014-March 2016 (\$/MMBtu)



Source: *The Indian Express* (2015).

The new pricing policy made provision for a premium (undefined) to be added to the formula price for high temperature and high pressure fields as well as deep water and ultra-deep water fields. In March 2016, the Cabinet approved a special pricing policy for existing but undeveloped discoveries and new discoveries in those fields. Domestic producers will be free to negotiate prices for production from those fields subject to a price cap (“calibrated marketing freedom”). The cap price, in gross calorific value, will be the lowest of the following:

- the landed import price of fuel oil;
- the weighted average trailing one year landed import prices of coal (30%), naphtha (30%) and fuel oil (40%); and
- the landed import price of LNG.⁸⁶

The ceiling price will be adjusted every six months. The government expects the prices for production from these fields to be 70-80% higher (around \$6.50-\$7.00/MMBtu, gross calorific value) than current levels. It remains to be seen if those price levels result in increased upstream investment. In any case, it will be at least several years before that production enters the market.

The government does not control LNG import prices. Contract LNG prices have been around \$12-\$13.00/MMBtu until the 2015 renegotiation of the Qatar RasGas - Petronet contract LNG price, which

⁸⁵ Government of India, Report of the Committee on Gas Pricing, 2014.

⁸⁶ *The Hindu* (2016).

lowered the price by linking it to a three-month trailing average of Brent crude oil prices.⁸⁷ In return for the price concession, Petronet agreed to increase contract volumes from 7.5 MMTPA to 8.5 MMTPA. The new contract price is currently in the range of \$5-\$6.00/MMBtu and the “landed price” for end-users is estimated to be \$8.50-\$9.00/MMBtu. Although the price competitiveness of LNG is improved, liquid fuels will continue to pose competition in the current oil price environment.

The government has had to devise special pricing schemes for gas-fired, grid-connected power plants and urea fertilizer plants. These two sectors represented about 55% of total gas consumption in 2014-15 and have required government natural gas price subsidies in order to remain commercially viable. Urea fertilizer producers have not been able to recover their production costs from farmers that pay government subsidized low prices for fertilizers. As a result, urea production has remained flat for several years leading to increased more expensive urea imports that increased the government subsidy burden. The annual central government subsidy for urea is close to 75% of its production cost and is estimated to be 21% or \$580 billion of estimated total subsidies in 2015-16).⁸⁸

In July 2015 the Cabinet approved gas price pooling for urea fertilizer producers. LNG prices will be averaged with domestic gas prices to produce a uniform lower gas price. As a result, urea fertilizer production is expected to increase 9% in 2015-16 and to decrease the government subsidy burden.

Gas power generators have not been able to sell their more expensive power (compared to coal-fired power) to electric distribution companies because the distribution companies cannot recover their costs due to controlled low end-user power prices. As a result, gas-fired power plants have been completely stranded or operated at load factors well below 30%, further exacerbating the overall power supply deficit in India and the non-performing loan burden of commercial banks.

In 2014 the government introduced a scheme whereby LNG prices were subsidized (\$35 billion in 2015-16) to bring gas-fired generation load factors up to 30%. This scheme will continue in 2016-2017 and the subsidy burden is expected to decrease as gas prices have dropped.

In order for the large gas consuming sectors of fertilizers and power plants to accommodate market natural gas prices and remain commercially viable on a stand-alone basis, basic reform of their business models is required. The government is taking some initial steps to do this in both sectors. However, the magnitude of the required reforms suggest that it will be a long process that is highly political. Government support for both sectors is highly likely to continue in the near term.

The Petroleum and Natural Gas Regulatory Board (PNGRB) regulates both pipeline and city gas distribution transportation tariffs. With respect to interstate pipeline transportation, regulated tariffs are set on a three-zone basis with an incremental charge for every 300 km. There are also marketing fees and taxes that must be recovered from end-user prices. In 2011, it was estimated that the total cost to transport gas from the east coast to the west coast was \$1.15/MMBtu.⁸⁹ Pipeline tariffs currently reported by GAIL India on its web site are less than \$1.00/MMBtu. It appears that most natural gas sales are done on a bundled basis with GAIL accounting for 51% of the volume. India does have a mandatory

⁸⁷ *The Hindu Business Line*, 1/2/16.

⁸⁸ DNA India, 12/28/15.

⁸⁹ The Energy and Resources Institute (TERI), March 2016.



open access policy for third parties to utilize spare pipeline capacity. However, demand for this service has been muted in light of domestic gas shortages and high LNG prices.

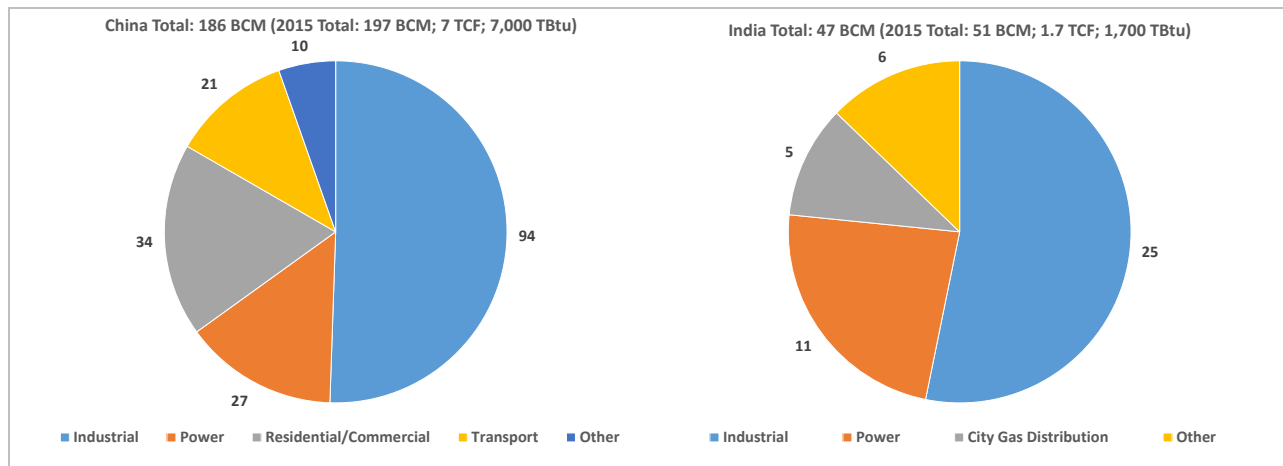
Licenses to own, construct and operate CGD systems are given by the PNGRB. The gas sales price for all CGD customer sectors is not controlled, although states have intervened in the past to prevent price increases.⁹⁰ The main competitors to natural gas in the piped natural gas (PNG) market for residential and commercial customers, and in the compressed natural gas (CNG) market for vehicles are subsidized liquid petroleum gases (LPG), and gasoline and high speed diesel, respectively. In late 2015, PNG was competitive with subsidized LPG due to the CGD sector’s increased allocation of domestic gas (as a function of its number one Tier 1 position)⁹¹ which saw an 18% price reduction in October 2015. In December 2015, the government eliminated the LPG subsidy for higher income consumers while maintaining it for poor consumers. With the subsidy removal, PNG is estimated to be 33% cheaper than LPG for those higher income consumers.⁹² Prior to the RasGas – Petronet LNG contract renegotiation, demand from industrial PNG customers was weak but could improve with the lower contract prices.

Gasoline and diesel prices are effectively de-controlled. However, the natural gas demand from the CNG market has been slowing as gasoline and diesel prices have fallen with crude oil prices. However, in December 2015, the Indian Supreme Court banned the registration of new diesel vehicles in 13 cities, including Delhi, and directed all taxis in Delhi to convert to CNG.

Natural Gas Consumption Detail

Industrial and power generation applications constituted the larger shares of gas utilization for both countries in 2014.

Figure 21. Natural Gas Consumption in China and India by Sector 2014



Sources: NBSC and MOPNG as revised by CEE (See APPENDIX 2 for revisions). BP Statistical Review 2016 has total Chinese gas consumption at 188 BCM. MOPNG reported India’s total gas consumption of 47 BCM. BP SR 16 has total gas consumption at 51 BCM.

⁹⁰ Sen, A., April 2015.

⁹¹ In July 2014, the Modi government revised the priority order of the Gas Utilization Policy: city gas for households and transportation replaced fertilizer plants as the number one priority in Tier 1. Sen, A., April 2015.

⁹² ICRA, Indian Gas Utilities, December 2015.



As our sectoral analysis indicates, in spite of many inconsistencies and dilemmas in both historical data as well as published outlooks (see APPENDIX 2 for details), we do not expect substantial change going forward. However, gas use for power generation is easily challenged by competing fuels and technologies. The need to address inefficiency and over-capacity in China's industrial sector and success (or lack of) India's industrialization policies will dictate potential outcomes in that sector. Like China, India saw natural gas demand increase 9% for the three month period April-June 2016 compared with the same period in 2015 as a result of lower domestic and import prices. Indian LNG import prices declined from \$13.10/MMBtu in 2014 to \$7.50/MMBtu in 2015 and to about \$4.85/MMBtu in the first half of 2016.⁹³ In 2015-16, India consumed 46.62 BCM of gas, up 2.9% from 2014-15 and imported LNG of 21.31 BCM, up 15% from 2014-15.⁹⁴ LNG accounted for 44% of total gas supply April-July 2016.⁹⁵ On a monthly average basis, Indian gas consumption for April-July 2016 was up 17% compared to the average monthly consumption for 2014-15 and LNG imports were up 14% compared to the average monthly LNG imports for 2014-15. Like China, Indian LNG imports fell for the first time in 2016 in July by 2% compared to July 2015 due to a 12% increase in LNG prices from June 2016 to July 2016 and an increase in domestic gas production.⁹⁶

Total gas consumption in China increased from 107 BCM in 2010 to 186 BCM in 2014 reflecting the economic expansion resulting from the government's economic stimulus efforts after the 2009 global financial crisis. In India total gas consumption declined 23% from 61 BCM in 2011 to 47 BCM in 2014.⁹⁷ The decline in India's total gas use is attributable to large decreases in cheaper domestic gas supplies and the lack of substitutes given the relatively high price of imported LNG over the period. The industrial sector was the main driver of gas demand in both countries. The industrial sector's share of total gas use grew from 46% to 50% (2010 to 2014) in China accounting for 57% of the 79 BCM increase in total gas use. In India the industrial sector's share of total gas use grew from 38% to 52% from 2011 to 2014, a slight increase of 2 BCM, reflecting lower total gas demand in 2014 rather than significant industrial sector gas use growth.

In both countries the power sector's share of total gas use declined: from 17% to 14% in China (2010-2014) and from 38% to 23% in India (2011-2014). India's power sector gas use declined 12 BCM due to the gas supply and price issues mentioned previously whereas China's power sector gas use increased by 9 BCM.

The residential/commercial sector remained the second largest gas consuming sector in China over the period growing by 11 BCM to account for 18% of total country gas use in 2014. Gas use in the city gas distribution (CGD) sector in India remained flat and accounted for 11% of total Indian gas use in 2014. The 2014 CGD sector in India was much smaller (5 BCM) than the 2014 residential/commercial sector in China (34 BCM) reflecting more rapid urbanization and rising household incomes in China as well as more rapid build out of gas distribution infrastructure.

⁹³ Sikorski and Tertzakian, 2016.

⁹⁴ Petroleum Planning & Analysis Cell, Ministry of Petroleum and Natural Gas, 2016, August, Historical and Current Trend of Natural Gas Consumption, http://ppac.org.in/content/152_1_Consumption.aspx.

⁹⁵ Ibid.

⁹⁶ Sikorski and Tertzakian, 2016.

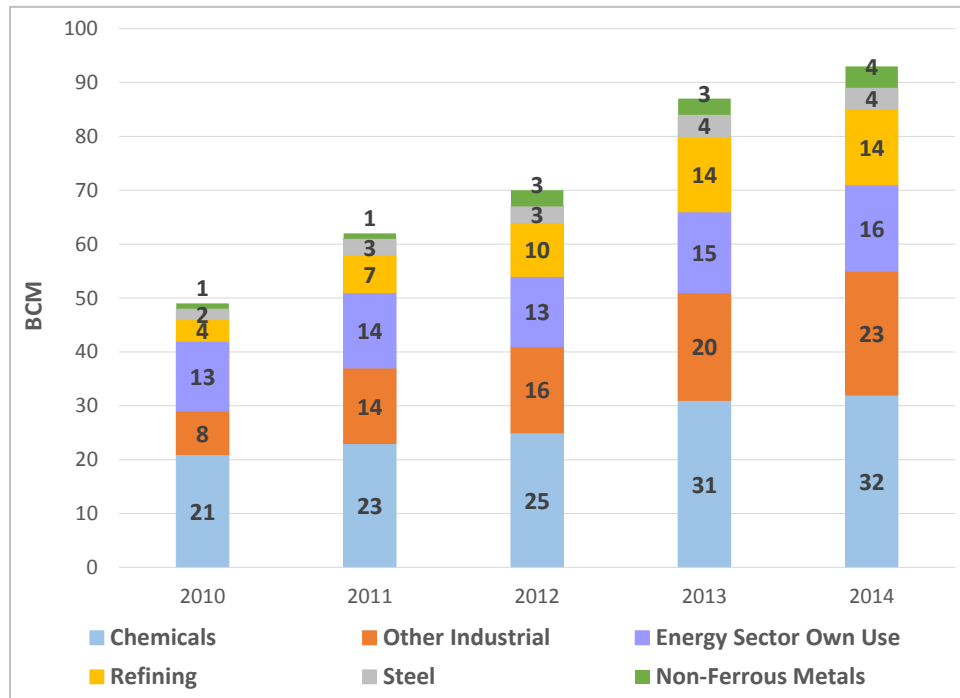
⁹⁷ MOPNG data prior to 2011 does not include consumption of LNG.

Transport sector gas use in China almost doubled between 2010 and 2014 increasing from 11 BCM to 21 BCM. The Chinese government strongly supports development of a natural gas vehicle (NGV) fleet, primarily for public vehicles such as buses, taxis and some trucks in order to improve urban air quality. However, transport sector gas use growth in China slowed in 2015 as natural gas price decreases lagged the drop in oil prices and the corresponding drop in diesel and gasoline prices. India’s transport sector gas use is included in CGD gas use and is very small. Some Indian cities like New Delhi are encouraging NGVs to improve air quality but sector development is in its infancy and impeded by currently cheap and more abundant alternatives.

Industrial Sector

The largest consumer of natural gas in both China and India is the industrial sector representing about 50% of total gas use in each country. China consumed more than three times as much natural gas in the industrial sector as India in 2014: 94 BCM in China versus 25 BCM in India. Leading industries differ. In 2014 in China, the chemicals industry represented 34% of total industrial gas use, followed by the diversified other industrial (25%), energy sector own use (17%)⁹⁸ and refining (15%) industries. In contrast, the Indian fertilizer industry, which receives heavily subsidized natural gas in order to support the farmers in India, represented 62% of total industrial gas use in 2014. Refining, petrochemicals, and energy sector own use (primarily LPG shrinkage) follow at 19%, 12% and 6%, respectively, of total industrial gas use.

Figure 22. Industrial Gas Consumption by Sector in China (BCM)

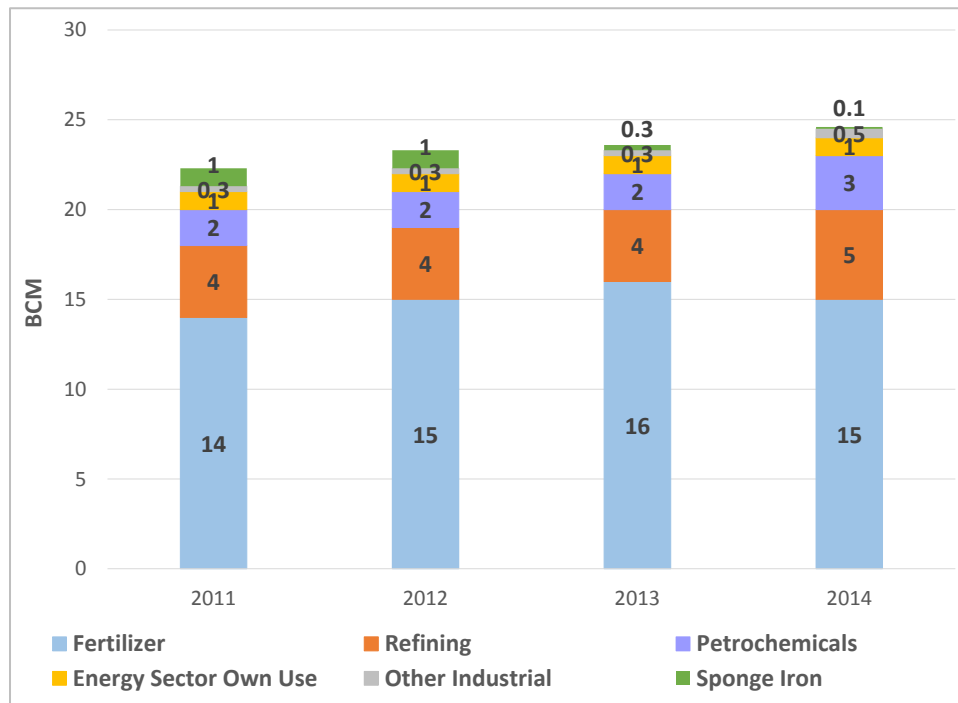


Source: NBSC as revised by CEE (See APPENDIX 2 for revisions)

⁹⁸ 94% of gas use is for oil and gas extraction and 6% for gas production and distribution.



Figure 23. Industrial Gas Consumption by Sector in India (BCM)



Source: MOPNG as revised by CEE (See APPENDIX 2 for revisions). MOPNG data before 2011 does not reflect consumption of LNG.

In China, the greatest increases in industrial sector natural gas demand between 2010 and 2014 occurred in other industrial categories (15 BCM), chemicals (11 BCM) and refining (10 BCM). Increases in Indian industrial sector gas demand between 2011 and 2014 occurred in fertilizer (1.2 BCM) and petrochemicals (1 BCM), offset by a decrease in sponge iron gas use (1.2 BCM).

The forecasts we reviewed (see APPENDIX 2) expect robust industrial sector gas demand growth in China. The EIA has the most aggressive industrial sector gas demand growth forecast expanding by a factor of three from 2012 (73 BCM) to 2030 (213 BCM). The EIA forecast is driven by increased gas demand from the chemicals sector as well as the non-energy-intensive manufacturing sectors.⁹⁹ These latter sectors are included in our “other industrial” category and consist of industries that are small gas consumers currently but have grown rapidly in recent years and should continue to expand in a services-led economy. The IEA forecasts industrial gas demand growth to grow 66% from 75 BCM in 2013 to 124 BCM in 2030 resulting from chemicals sector gas use growth as well as environmental policy-driven fuel switching from coal to gas. The same factors drive the Energy Insights McKinsey industrial gas demand growth of 53% between 2016 (103 BCM) and 2030 (158 BCM). ICIS expects flat to slow growth in the chemicals sector in the near term but expects non-chemicals industrial/commercial gas demand growth to increase 51% between 2016 (75 BCM) and 2020 (114 BCM).

⁹⁹ EIA IEO 16. Non-energy-intensive manufacturing includes fabricated metal products, machinery, computer and electronic products, transportation and electrical equipment. All of these are included in our “other industrial” category.



Chemicals

The chemicals sector accounted for 34% and 12%, respectively, of China and India's total industrial gas use in 2014. ExxonMobil (2016) asserts that "chemicals production is the fastest-growing source of industrial energy usage" globally. China's chemicals industry has experienced rapid growth. According to IHS analysts, China is now the world's largest consumer of chemicals driven by consumer goods manufacturing and growing domestic consumption.¹⁰⁰ Morawietz et al. (2015) states that China's chemical sales expanded at an average compound rate of 26% from 2005 to 2015. Chemicals are the building blocks for plastics which are in many consumer products. China's plastics production grew at an average annual rate of 14% 2005 to 2014.¹⁰¹

Growth in China's commodity petrochemicals demand such as polymers, propylene and polypropylene is slowing according to Hong et al. (2013) and Viswanathan (2015). Nevertheless, China is expected to increase capacity in some commodity chemicals like naphtha-based ethylene in the near term, driven by the desire to reduce imports. In the first eight months of 2016, China's ethylene output increased 6.6% year-on-year with plastics production rising 7.9% over the same period.¹⁰²

The chemicals industry is moving increasingly toward the production of high-end specialty chemicals, which are used in sectors such as pharmaceuticals, coatings, infrastructure, information technology and automobiles. IHS Specialty Chemicals Update Program (2015) expects consumption of specialty chemicals in China to grow about 7% per year to 2019, down slightly from 8-9% historically. BMI says that the growth potential in Chinese chemicals lies in higher value-added products, not the basic petrochemicals that drove historical demand increases.¹⁰³ IHS notes that Chinese and Indian manufacturers have become key players in several specialty chemical markets and expects the trend to continue. However, the sector's rapid growth has led to overcapacity in some commodity and specialty chemicals products depressing profitability, and BMI expects that near term capacity increases will outpace demand growth.¹⁰⁴ However, environmental opposition to chemical plants increased significantly following five chemical explosions in 2015 and could slow the announced capacity expansions.¹⁰⁵ Combating overcapacity and shutting down inefficient plants in the sector is expected to be a focus in the 13th Five-Year Plan under development in 2016 although the timing and magnitude of such measures are uncertain.

India's petrochemical sector is expected to expand driven by demand from the textile, automobile and food packaging industries. BMI expects India's demand growth (8% p.a. 2014-2024) for polypropylene and polyethylene to outgrow China's (6% p.a. 2014-2024) in the future as India's per capita consumption is very low compared to Chinese and global per capita consumption of those products. Currently India's ethylene/polymers industry is much smaller than China's: in 2013-2014 India had 9 operational ethylene

¹⁰⁰ Pang, et.al., 2016.

¹⁰¹ NBSC, 2016.

¹⁰² BMI Research, 2016, Q4, China Petrochemicals Report.

¹⁰³ Ibid.

¹⁰⁴ BMI Research, 2016, Q2, China Petrochemicals Report.

¹⁰⁵ Ibid. A chemical explosion in September 2015 killed around 150 people. A review following the disaster identified up to 1,000 chemical units that needed to be relocated and/or upgraded at an estimated cost of about \$70 billion.



crackers compared to 58 in China according to Mistry (2014). At the time, China had 18 ethylene cracker projects in progress compared to three in India.

The supply/demand balance for Indian polyethylene is expected to remain in deficit through 2025 and the balance for polypropylene is expected to change from surplus to deficit by 2022 (Mistry, 2014). The IEA expects ethylene production to increase from 3 million tonnes in 2013 to 13 million tonnes by 2040. Nevertheless, BMI sees threats to new chemicals capacity additions in India due to policy formation and execution problems, the high cost of domestic capital and development delays in environmental clearances, land acquisition and general bureaucratic approvals.

The expected demand growth for Indian petrochemical products offer a solid rationale for new capacity to be developed. However, investment in new capacity to date has been limited owing to many of the challenges faced by Indian corporate and public sectors as discussed earlier in this report. In addition, industrial centers in India are regionally fragmented. The chemicals sector benefits from clustering to achieve scale and integration. The central government has a cluster initiative, the Petroleum, Chemicals and Petrochemical Investment Regions, and has approved four locations but only one project has made any significant progress because of “excessive interference and control by the state and failure to actively involve the private sector.”¹⁰⁶ Foreign direct investment in the sector is permitted but has not been forthcoming due to “policy paralysis, poor infrastructure, and complex legal, tax and regulatory regimes.”¹⁰⁷

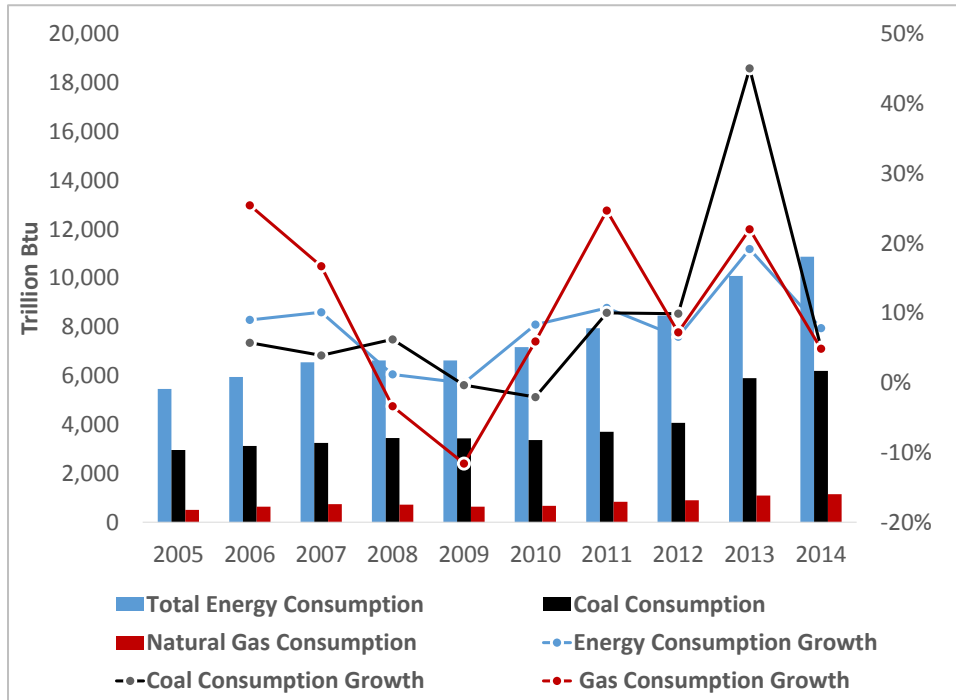
The chemicals sector is the largest industrial consumer of natural gas in China accounting for 34% of total industrial natural gas demand in 2014. The chemicals sector uses naphtha, fuel oil, natural gas and coal as both fuel and feedstock. The chemicals sector’s natural gas consumption grew at an average annual rate of 10% from 2005 to 2014 outpacing total average energy demand growth of 8% over the same period. The share of natural gas in chemical sector energy demand increased from 8% in 2005 to 9% in 2014 (Figure 24). Natural gas has some advantages as a fuel in integrated refinery and petrochemical complexes. However, unlike many countries, the Chinese chemicals sector also uses coal as a fuel and as an alternative feedstock and the coal-fired chemical capacity is expected to expand according to ExxonMobil (2016). Both coal and gas use in the sector grew at an average annual rate of about 10% 2005 to 2014. The share of coal in total gas use increased from 54% in 2005 to 57% in 2014.

¹⁰⁶ IHS Chemical Week, 2/10/14.

¹⁰⁷ Ibid.



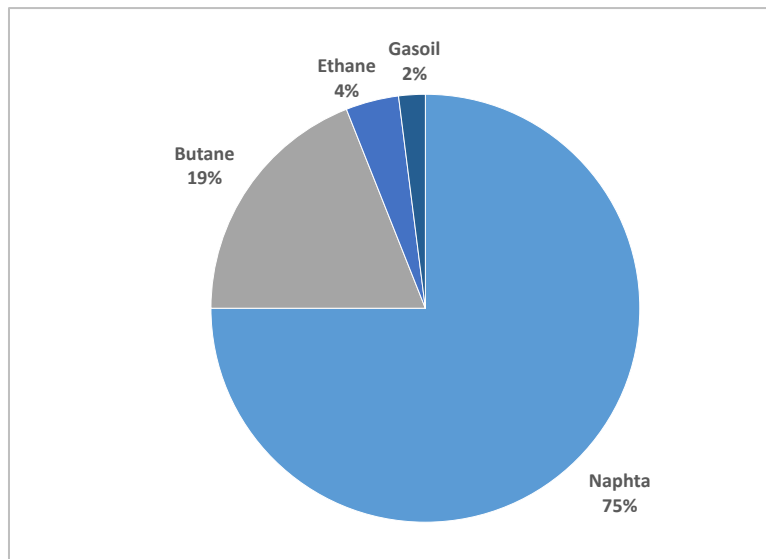
Figure 24. Chemicals Sector Use of Gas and Energy in China



Source: NBSC, CEE estimates 2014 and 2015

China leads the world in the expansion of ethylene and propylene production. China's plants are heavily dependent on naphtha generated by its refining sector as well as imported naphtha (Figure 25).

Figure 25. China Total Petrochemical Cracker Feedstock by Fuel, 2016¹⁰⁸



Source: BMI Research, 2016, China Petrochemical Report 4Q

¹⁰⁸ BMI Research, 2016, Q2, China Petrochemicals Report.



In an effort to become feedstock self-sufficient, China has invested in coal-to-olefins technology. According to Orr (2012), Chinese chemical companies have invested heavily in technologies like coal-to-olefins.¹⁰⁹ China's investment in unconventional chemicals production was estimated at \$20 billion in 2015 alone.¹¹⁰ Coal consumption for coal-to-liquids projects grew at an average annual rate of 31% between 2010 and 2013.¹¹¹ IHS projects that by 2020, 40% of olefins in China will come from unconventional feedstocks such as methanol, coal and propane, up from 20% in 2015.¹¹²

China has added more than 9 million tonnes of ethylene capacity between 2010 and 2015 and is expected to add at least 7 million tonnes of new capacity between 2015 and 2019 according to IHS Chemical. In 2015, a great majority was coal/methanol based. However, BMI cautions that capacity utilization rates for coal-based polyethylene plants was 65%-70% to date in 2016, down from over 80% in 2015.¹¹³ The cost of naphtha-based polyethylene is now cheaper than coal-based production and is negatively impacting margins. The economics of coal and methanol based ethylene projects are poor at oil prices below \$90/Bbl.¹¹⁴ As a result, BMI expects delays or cancellations of announced new coal and methanol based ethylene capacity but sees naphtha based ethylene capacity almost doubling over the next five years.¹¹⁵

The operating rate for coal-based polypropylene plants has been around 75% year to date according to BMI. Integrated coal-to-olefin polypropylene projects produce the lowest priced polypropylene in China's domestic market and is expected to account for more than 50% of new capacity in 2016.¹¹⁶

There are mixed outlooks in the natural gas demand forecasts we reviewed for coal and methanol-to-olefins technologies in China (see APPENDIX 2). ICIS expects the chemicals sector share of total Chinese gas demand to drop from 13% in 2016 to 9% in 2020 because "natural gas usage as a chemical feedstock is not encouraged by the state government."¹¹⁷ BMI expects fuel use in the chemicals sector to be dominated by coal and naphtha. Other forecasters like McKinsey Energy Insights, IEA, and EIA are more positive. McKinsey expects gas use in the chemicals sector to "stabilize" as "industrials will replace coal and heavy oil with gas under pressure from local governments" to combat pollution.¹¹⁸ Similarly, IEA expects industrial gas use in China to increase by a factor of four driven by "gas demand from the petrochemical sector and a policy-driven switch from coal use especially in and around urban areas."¹¹⁹ The EIA expects the coal share of chemical feedstock fuel to increase from 20% to 32% between 2012 and 2040, primarily displacing naphtha. However, the EIA thinks that the natural gas share of chemical feedstock use will also increase as gas is used more heavily in ammonia and methanol production which is currently dominated by coal with a 70-80% share of feedstock use.¹²⁰ In its 2016 Outlook for Energy,

¹⁰⁹ Orr, 2014.

¹¹⁰ Pang, et.al., 2016.

¹¹¹ NBSC, 2016.

¹¹² Pang, et.al., 2016.

¹¹³ BMI Research, 2016, China Petrochemicals Report Q4

¹¹⁴ Ibid.

¹¹⁵ Ibid.

¹¹⁶ Ibid.

¹¹⁷ ICIS, 2016.

¹¹⁸ Energy Insights, 2016.

¹¹⁹ IEA WEO 15.

¹²⁰ EIA IEO 16.



ExxonMobil projects that Asia Pacific chemical sector fuel and feedstock use will be heavily dominated by naphtha, with coal as an alternative chemical feedstock in China.¹²¹

Given the magnitude of the non-natural gas capacity additions to date, we expect chemical sector natural gas demand growth to slow from historical growth rates. Chemical sector gas use was flat between 2013 and 2014. The Chinese chemical sector will continue to expand fueled primarily by naphtha and coal. Significant growth in natural gas use in the sector would depend on price relative to alternatives and aggressive implementation of government policies regarding pollution. The latter has been limited thus far.

The key chemical sector developments in China to monitor going forward are:

- (1) the magnitude and timing of unconventional feedstock growth;
- (2) the magnitude and timing of carbon emissions policies and the relative impacts on fuel costs and the sector;
- (3) chemical sector growth itself in a world of overcapacity and pressured margins;
- (4) reduction of sector overcapacity, and
- (5) local resistance to sector capacity reductions and continuation of subsidies.

The Indian petrochemicals sector currently relies primarily on domestic naphtha from its refineries as feedstock and this is expected to continue. Natural gas has played a limited role to date due to lack of domestic supplies, relatively high LNG prices, and limited distribution infrastructure. Petrochemicals is a Tier 2 gas consumer and almost 50% of its gas supply has come from higher priced LNG. As with refining, LNG prices were not a big issue when naphtha prices were high, but competition has intensified as crude oil prices dropped. The December 2015 renegotiation of India's Qatar LNG contract will move LNG prices into the single digits. If India could successfully develop integrated refinery/petrochemicals complexes, natural gas could possibly have some advantages. Unlike China, India has not made a big investment in unconventional feedstock technologies such as coal because India's domestic coal resources contain limited levels of sub-bituminous coal which is preferred for chemicals production.¹²² Some companies, including GAIL and Reliance, are planning to import cheap U.S. ethane for existing (Reliance) and new (GAIL) plants. Reliance has executed agreements for their ethane imports, including orders for six very large ethane carriers.¹²³ ExxonMobil projects that Asia Pacific chemical sector fuel and feedstock use will be heavily dominated by naphtha, with coal as an alternative chemical feedstock in China.¹²⁴

In view of the subdued level of forecast capacity additions in the Indian petrochemicals sector for the next 6-10 years (it takes at least 8 years to construct a new petrochemicals plant), it is difficult to see much near term natural gas demand growth in the sector. There should be moderate growth thereafter depending on the success of improving the overall business environment in India and successful implementation of the clustering concept.

¹²¹ ExxonMobil forecasts that global use of naphtha and NGLs in the chemical sector will increase by 70% and 90%, respectively, by 2040. Also see footnote 118.

¹²² Sub-bituminous coal is cleaner, lighter and easier to extract than anthracite coal. The latter is the majority of India's coal resources whereas almost 50% of China's coal is sub-bituminous (Mistry, 2014).

¹²³ www.livemint.com, 2/1/16.

¹²⁴ ExxonMobil forecasts that global use of naphtha and NGLs in the chemical sector will increase by 70% and 90%, respectively, by 2040. Also see footnote 118.

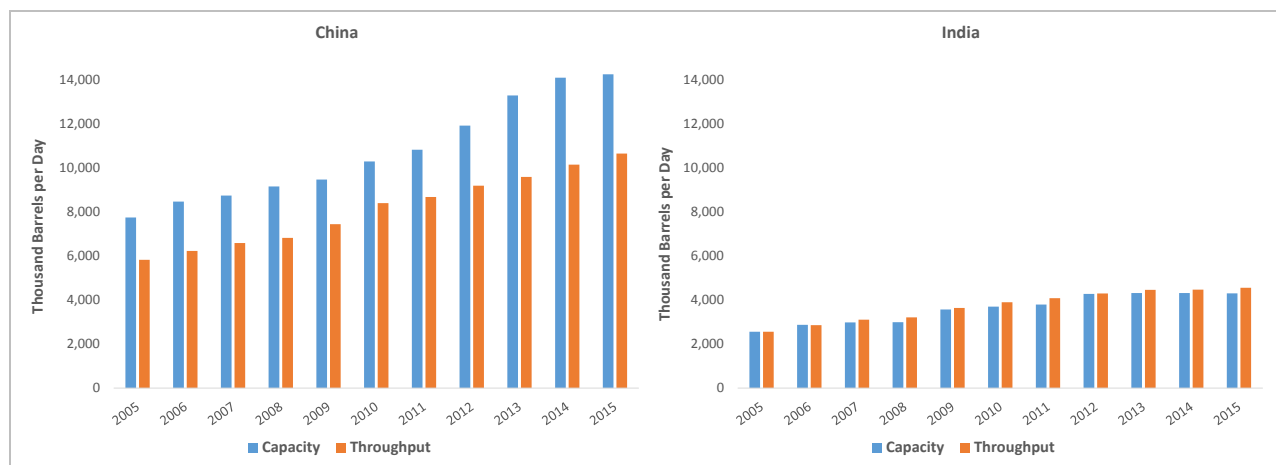


Refining

Overcapacity in the refining sector exists globally, regionally in Asia, and in China domestically with downward pressure on utilization and margins, according to Fitzgibbon and Janssens (2015). These authors expect utilization rates to fall further in Asia with improvements possibly beginning in 2020.

China has been adding refining capacity at an average annual rate of 6% between 2005 and 2015 in order to meet local demand. Refinery sector investment grew at an annual average rate of 17% from 2005 to 2014. However, refinery capacity utilization rates have decreased from the peak of 82% in 2010 to 72% in 2014, before increasing to 75% in 2015. BMI Research reports a refinery capacity utilization rate of 75.7% for the first five months of 2016 and estimates that more than a quarter of the country’s refining capacity remains idle.¹²⁵ India has the fourth largest refining capacity in the world after the U.S., Russia and China but its capacity is less than one-third of the capacity in China. The public sector owns 59% of refining capacity while the private sector operates 35% with the remaining 6% operated by joint ventures. Refining capacity grew 7-8% on average until 2012-13 (slightly higher than China at 6%) in India on the back of strong private sector investment in the sector from companies like Essar Oil and Reliance, after which the growth stagnated until the addition of the Paradeep refinery in late 2015. Throughput in India is about 43% of that in China.

Figure 26. Refinery Capacity and Throughput in China and India



Source: BP Statistical Review of World Energy 2016. India data do not include the 15-million tonne Paradeep Refinery commissioned in November 2015

BMI expects Chinese refined products consumption to slow markedly in coming years from 5% per annum growth 2011-2015 to 1.3% p.a. 2016-2025 due to China’s ongoing economic slowdown and its shift to a services-led economy.¹²⁶ Diesel demand in particular is weakening due to the contraction in the more diesel intensive manufacturing and construction industries. Residual fuel oil (RFO) consumption will suffer negative impacts from stricter emissions laws and higher fuels standards. In addition, small private refiners are replacing RFO as a feedstock with imported crude oil since they were allowed to import crude oil for the first time in early 2014. Gasoline demand is expected to grow but there is a growing oversupply in the domestic and regional markets which could lead to near term

¹²⁵ BMI Research, 2016, 4Q, China Oil & Gas Report.

¹²⁶ Ibid.

production cuts. As a result of flagging domestic demand, China became a small net exporter of refined products (primarily jet fuel and diesel) for the first time in 2015.¹²⁷ Exports of middle distillates like jet fuel and diesel are expected to increase, but China should return to being a net refined products importer driven by gasoline, LPG and, to a lesser extent, residual fuel oil imports.

In spite of slowing demand growth, BMI reports that PetroChina and Sinopec, which together control about 60% of the industry, are planning to construct five new refineries over the next five years. Others, such as Fitzgibbon and Janssens (2015) think that the refining industry will slow down or defer new projects. The industry's focus could shift away from new capacity additions and towards the modernization of existing facilities as fuel standards tighten domestically and in export markets. In August 2016 the government issued new guidelines aimed at reducing overcapacity in the refining and petrochemical industries. However, some analysts characterize the guidelines as vague; that the enforcement will be "spotty;" and that they will not result in a meaningful reduction in overcapacity.¹²⁸

India has had surplus capacity in refining relative to its domestic demand for refined products. The surplus capacity has been utilized to generate exports. As a result, Indian refineries, unlike China, have consistently operated above design capacity and their refined products exports accounted for about 15%-20% of the value of total exports in recent years.¹²⁹ Essar Oil and Reliance account for 80-90% of India's refined products exports.¹³⁰ Reliance owns the largest refinery in the world (1.2 million barrels/day capacity). Even though domestic oil products consumption has grown at an average annual rate of about 4%, production has thus far outstripped domestic demand.

However, the volume of refined products exports dropped 10.5% and 19% in 2014 and 2015, respectively.¹³¹ India's surplus refining capacity is being increasingly utilized to meet strong domestic demand growth spurred by low fuel prices and a rapidly expanding vehicle fleet. Domestic demand grew at 4.1% in 2014, 8% in 2015 and 11% through August 2016. The largest demand increase has been for gasoline, followed by LPG and diesel. Diesel is used heavily in the industrial sector which is expected to expand. Aided by supportive subsidies the government wants LPG to displace kerosene in the residential sector and increase its market share by 20%. BMI expects average domestic demand growth of 4.4% p.a. 2017 to 2021 dropping to 3.5% thereafter. India's refined products consumption will outpace the 1.3% p.a. forecast annual growth rate for refined products consumption in China.¹³²

However, neither IEA nor BMI expect significant refinery capacity additions going forward. After the Paradeep refinery, the IEA expects only two smaller projects to be completed before 2020.¹³³ BMI forecasts very limited capacity growth between 2017 and 2025. The IEA expects refinery capacity

¹²⁷ Ibid.

¹²⁸ The guidelines' weakness is attributed to the government's contradictory goals for the sectors: Curbing overcapacity while attracting more private capital into the sector. Meidan, 2016.

¹²⁹ 2016, February, ITP Division, Ministry of External Affairs, Monthly Economic Bulletins, <http://www.indembkwt.org/Monthly%20Economic%20Bulletin%20%20February%202016.pdf>

¹³⁰ The Oil and Gas Year, 3/24/15.

¹³¹ BMI Research, 2016, Q3, India Oil & Gas Report.

¹³² Ibid.

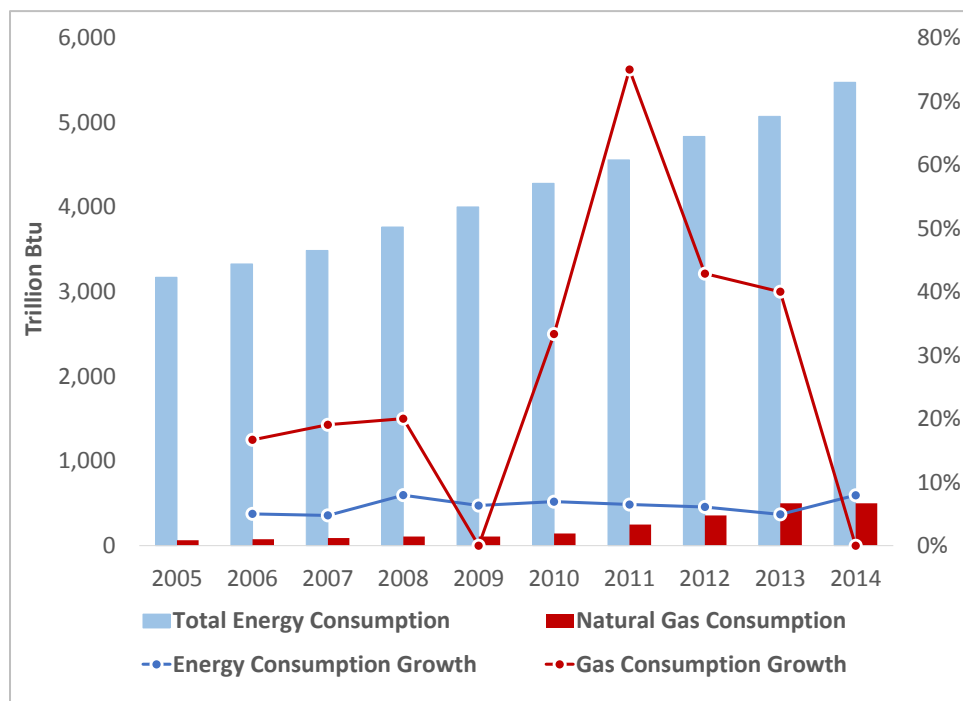
¹³³ IEA WEO 15.



additions to continue post-2020, moderated by competition from China and the Middle East in export markets. By 2030, the IEA expects domestic oil products demand to outstrip domestic capacity.

Natural gas use in the Chinese refining industry substantially outgrew GDP growth between 2005 and 2014: an estimated 27% versus 10%. The natural gas market share of total refining sector energy use grew from 2% in 2005 to 10% in 2013, dropping to 9% in 2014 (Figure 27).¹³⁴ In recent years refining natural gas demand grew faster than total energy demand that averaged 6% between 2005 and 2014. Competing fuels include naphtha, fuel oil and coal: gas competes with fuel oil and coal as a fuel for process and utility heaters and with naphtha as feed and fuel for hydrogen generating units and as fuel for gas turbines according to Taraphdar et al. (2012). Taraphdar et. al. (2012) also advocate natural gas use in integrated refinery and petrochemical complexes to enable recovery of valuable components from refinery off-gases; to facilitate the release of good quantities of naphtha; to enable more middle distillate production; and to reduce the carbon footprint. When there is a large differential between high crude oil and lower natural gas prices, natural gas use enhances refinery/petrochemical complex profitability. These favorable price differentials existed in 2012-2013 when refinery gas use increased rapidly in China but narrowed in 2014-2015. China's naphtha imports surged in 2014-2015 as naphtha prices plunged to six-year lows in 2015, down more than 50% from the previous year and there are predictions for sustained low naphtha prices¹³⁵ Wholesale fuel oil prices also fell after the collapse of the oil price and were around \$8/MMBtu in 2015. While coal is utilized in the refining sector, estimates of use are not reliable.

Figure 27. Refining Sector Use of Gas and Energy in China



Source: NBSC, CEE estimates 2014

¹³⁴ National Bureau of Statistics China, 2016, <http://data.stats.gov.cn/english/easyquery.htm?cn=C01>

¹³⁵ BMI Research, 2016, Q2, China Petrochemicals Report.

For China's refining sector, we can see scenarios in which refining sector energy demand growth is lower than historical growth rates or flat at 2015 levels as the sector deals with overcapacity and weak profitability through 2020. Continuation of low coal, naphtha and fuel oil prices could also inhibit natural gas consumption growth in the sector although the fuel oil price floor will keep that price from dropping further. China's domestic production of naphtha is expected to increase in the near-term keeping downward pressure on prices.

The key developments to monitor in the Chinese refining sector are: (1) the timing and magnitude of throughput improvement; (2) the relationship among natural gas, coal, naphtha and fuel oil prices; (3) the level of refinery capacity expansions and (4) the domestic and import supplies of coal, naphtha and fuel oil.

Like China, in India natural gas competes with naphtha, fuel oil and coal in the refining sector. Essar Oil uses coal to power its refineries, saving 15% in power costs, while others use naphtha, fuel oil and diesel. India's refining sector gas use represented 19% of total industrial gas use in 2014. Refining sector gas use did not increase much (.3 BCM) between 2011 and 2014 as it was constrained by lack of supplies, due either to price or infrastructure limitations. As a Tier 2 natural gas consumer, LNG has been a significant component of the refining sector's supply estimated at about 45% in 2012-13. Until the recent drop in crude oil prices, refineries could tolerate the relatively high LNG prices because naphtha and fuel oil were even more expensive.

Growth in Indian refining sector natural gas demand growth through 2020 is dependent on the persistence of currently low LNG import prices and the ability of the gas infrastructure (terminals and pipelines) to deliver gas to refining demand centers. It is not clear how much additional gas could be delivered to the sector without significant infrastructure additions. Post-2020 moderate gas demand growth from the sector is possible as domestic oil products demand begins to offset possible demand losses in the export markets. Realizable gas demand growth depends on adequate gas delivery capacity as well as the price competitiveness of gas versus alternative fuels.

Steel

China accounts for over 50% of global steel production with private steel producers accounting for 76% of total capacity in 2013. Most of its production is commodity steel with higher margin specialty steel accounting for only 6% of output in 2013. China's steel production contracted 2.3% in 2015—the first contraction in 35 years according to Shepherd and Mitchell (2016a). Domestic steel demand was down about 4% in 2015 due to slowdowns in the construction (41% of demand in 2014) and heavy industries sectors.¹³⁶ Member companies of the China Iron and Steel Association had combined net losses totaling around \$10 billion in 2015 compared to profits of around \$3 billion in 2014¹³⁷

Nevertheless, the government, particularly at local levels, has been reluctant to close steel mills due to anticipated job losses. China has about 1.25 billion tonnes of annual crude steel capacity, with an estimated surplus capacity of 300 million tonnes: as of July, 2016, only 7% of the estimated surplus capacity was closed.¹³⁸ To date the industry has dealt with the overcapacity issue by increasing exports

¹³⁶ .Zacks Equity Research, 2016. The World Steel Association expects China's domestic steel demand to fall another 4% in 2016. A recovery in the Chinese construction sector appears unlikely in the near future.

¹³⁷ Shepherd and Mitchell, 2016.

¹³⁸ Shepherd, 2016; Lian and Stanway, 2015.

which were up 20% in 2015 (Shepherd and Mitchell, 2016a). China hot rolled steel prices fell by close to 50% between early 2013 and late 2015.¹³⁹ JP Morgan expects steel exports to have peaked in 2015 due to a “wave of protectionism”: 37 anti-dumping cases globally were filed against Chinese steel producers in 2015. However, despite tariffs imposed by the EU and the US in 2014 and 2015 steel exports have continued to grow.¹⁴⁰ On 3/4/16 the US imposed a 266% duty on imports of cold-rolled steel from China, used to make auto parts, appliances and shipping containers. Some industry analysts think that the government is propping up old industries like steel to ease the transition to a services-led economy.¹⁴¹ Steel mills have been regular recipients of substantial government subsidies since 2000, if not earlier.

The government announced on 2/29/16 that it plans to cut 38% of steel’s estimated 400 million tons of excess capacity by 2020 and that 1.3 million coal workers and 500,000 steel workers could expect to lose their jobs. 150 million tonnes of steel production are slated to be cut between now and 2020 per the 2015-2020 Five Year Plan.¹⁴² The government plans to establish a US\$15 billion fund to help resettle laid off workers.¹⁴³ The timing of the cuts is uncertain in the face of increasing social unrest.¹⁴⁴ In addition, local governments, which want employment and tax revenue, have a history of undermining central government reforms.

Ng (2016) expects steel output to drop another 2-3% in 2016, noting that “production cuts in a glut are a long drawn out process as mills seek to maintain market share.” In its 2015 World Energy Outlook, IEA (2015) expects China’s steel output to decline by 30% by 2040 with related energy demand following the same decline. In contrast, the EIA expects Chinese steel production to increase at an average annual growth rate of 3% from 2012 to 2040.¹⁴⁵ Fitch Ratings expects China’s steel production capacity to peak in 2016, with shutdowns outpacing additions over the next five years.¹⁴⁶ Domestic steel demand is expected to remain flat over the next few years barring major swings up or down in the real estate construction business.

India is the world’s largest producer of sponge iron, which is used to produce long finished steel that is primarily used in the construction sector. India’s steel production is growing but at lower rates as the global steel glut has persisted. ICRA (2016b) observes that out of the top 10 steel producing countries only India reported growth in steel production in calendar year 2015. In February 2016 the Indian government imposed Minimum Import Prices on 173 categories of flat and long steel products for six months. ICRA (2016b) expects this measure to effectively curb steel imports but expects domestic steel demand growth to remain muted. There is excess capacity in India’s domestic steel industry: the current utilization rate is 75% and 10-15 million tonnes of new capacity are being brought on-line. The Sponge

¹³⁹ SteelBenchmarker Report 249. 2016. Prices improved in 2016 and were down 36% as of August 2016 compared to early 2013.

¹⁴⁰ Dempsey, 2015.

¹⁴¹ Magnier, 2016.

¹⁴² Yang, 2016.

¹⁴³ Ibid. A steel industry participant said that China, as a socialist country, must secure the livelihood of its workers.

¹⁴⁴ Ibid. The China Labour Bulletin states that there has already been an increase in strikes and “workplace incidents: 503 incidents in Jan. 2016 –almost double the 272 incidents in Jan. 2015. Labor demonstrations doubled in 2015.

¹⁴⁵ EIA IEO 16.

¹⁴⁶ Fitch Ratings, 11/19/15.

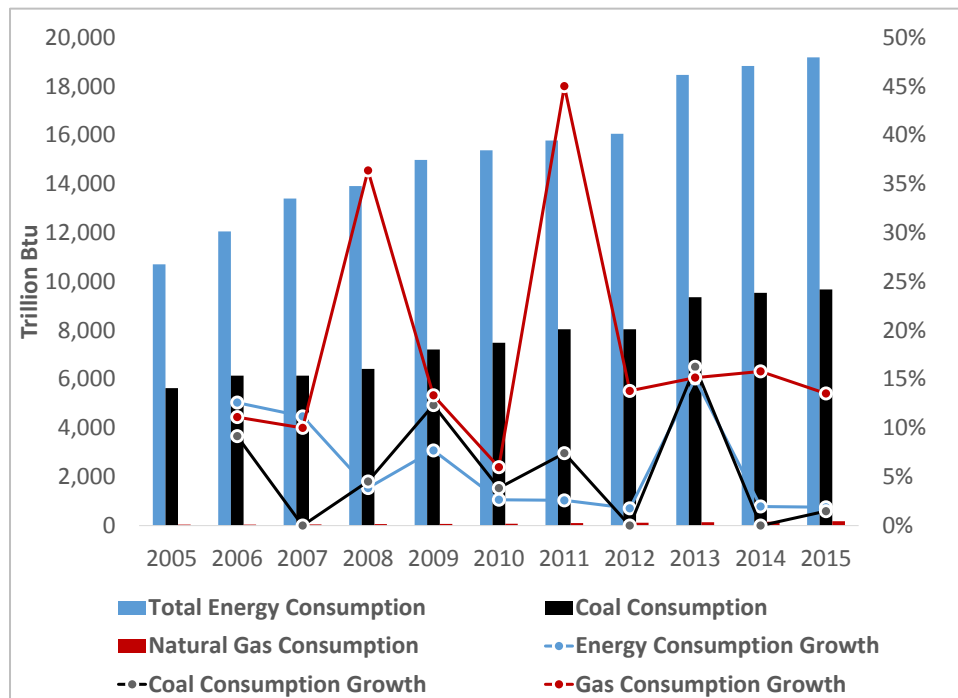
Iron Manufacturers Association (SIMA) is advocating that the government make “heavy expenditures” in infrastructure and housing to stimulate domestic steel demand.

Scrap steel is an alternative input to sponge iron and has advantages: it is easy to melt and it requires less fuel. Sponge iron demand in recent years has been hurt by low scrap steel prices and weak steel demand. China is projected to have a sizable scrap steel surplus going forward. SIMA is calling for new duties to be imposed on scrap steel imports.

Iron ore is the major input to sponge iron manufacture. Although global iron ore prices dropped 50% in 2014 and have remained weak thereafter, domestic iron ore producers have not lowered prices to global levels. About 50% of sponge iron producers have captive iron ore mines but the other 50% are exposed to market prices. Sponge iron producers are financially strained and 50% of the sector’s bank loans are reported to be non-performing.¹⁴⁷

China’s steel industry was the fifth largest industrial consumer of natural gas in 2014 (4.4 BCM) representing 4.7% of total industrial gas use. The government has encouraged the use of natural gas in the industry to address air quality issues. Natural gas consumption by the industry has grown at an average annual rate of 18% from 2005 to 2014 compared to 6% for coal over the same period. Natural gas increased its share of total steel energy use from 0.3% to 0.8% over the same period. However, coal continues to be a significant low-price competitor with a market share of 51% in 2014 down only slightly from 52% in 2005.

Figure 28. Steel Sector Use of Gas and Energy in China



Source: NBSC; CEE Estimates 2014 and 2015

¹⁴⁷ Sponge Iron Manufacturers Association, 2015.

Despite carbon reduction commitments, we expect that displacement of coal in the steel industry will be a long process. As IEA (2015) notes, “the switch away from coal [for industrials] is not easy, requiring time to plan and implement as well as significant capital investment.” Steel industry natural gas demand growth in the near term depends on continued growth in steel production. For the first half of 2016, Chinese steel production declined 1.1% year-on-year.¹⁴⁸ Resumption of natural gas demand growth at historical levels in the longer term also seems unlikely in an industry expected to contract by 30%. Barring the imposition of carbon costs that disadvantage the price of coal relative to the price of natural gas, we do not see the steel sector as a potential major growth market for natural gas.

India’s steel production is growing but at lower rates as the global steel glut has persisted.¹⁴⁹ In addition, non-coking coal-based production accounts for 90% of total Indian sponge iron production even though it consumes up to twice as much energy and generates more pollution than natural gas-based production.¹⁵⁰ Load factors for coal and gas sponge iron plants were 40% and 25% in 2014-15, respectively. SIMA reported gas supply shortages in late 2015 claiming that available gas met only 15% of the industry’s total gas requirements. 67% and 48% of the sponge iron sector’s gas supply was LNG in 2012-13 and 2007-2014, respectively. Reduced gas availability and high LNG prices saw sponge iron natural gas use drop sharply in 2013-14 and 2014-15.

The outlook for the Indian sponge iron sector is not vibrant. The sector’s current problems are daunting and the future appears to be veering away from it. Planned Indian primary steelmaking capacity expansions use blast furnaces and do not require sponge iron as an input. It is difficult to see much natural gas demand growth in this sector. The Vision 2030 sponge iron gas demand projections of 4 BCM by 2020 and 5 BCM by 2030 are probably on the high side. This is not a major growth market for natural gas.

Non-Ferrous Metals in China

The non-ferrous metals industry includes products like aluminum, brass, copper, and titanium to name a few. The aluminum industry is electricity-intensive but it also uses natural gas. Natural gas can be used to extract aluminum oxide (alumina) from bauxite and the alumina is further smelted using large amounts of electricity. Coal is a major competitor to gas in the total non-ferrous metals industry and had a 61% share of total sector energy use in 2014 compared to 3% for gas.

In China, aluminum production is one of the largest non-ferrous metals industries. According to Mukherji et al. (2015b), China now accounts for 50% of global aluminum production compared to 11% in 2000 with production growing at an average annual rate of 22% 2005-2015. China, the Middle East and Russia are currently the lowest cost aluminum producers driving prices down by 27% in 2015 according to Deaux (2015). Electricity is the primary energy source and China has some of the lowest cost aluminum production in the world due to many smelters owning captive coal mines to fuel their needed power (Home, 2015). Most smelters in southwest China do not have captive coal mines and are more vulnerable to shut downs.

¹⁴⁸ *Bloomberg News*, 2016, July 15.

¹⁴⁹ ICRA reported that out of the top 10 steel producing countries only India reported growth in steel production in calendar year 2015. ICRA, Indian Steel Industry, February 2016.

¹⁵⁰ According to IEA India is the only country in the world that uses coal for large-scale sponge iron production.

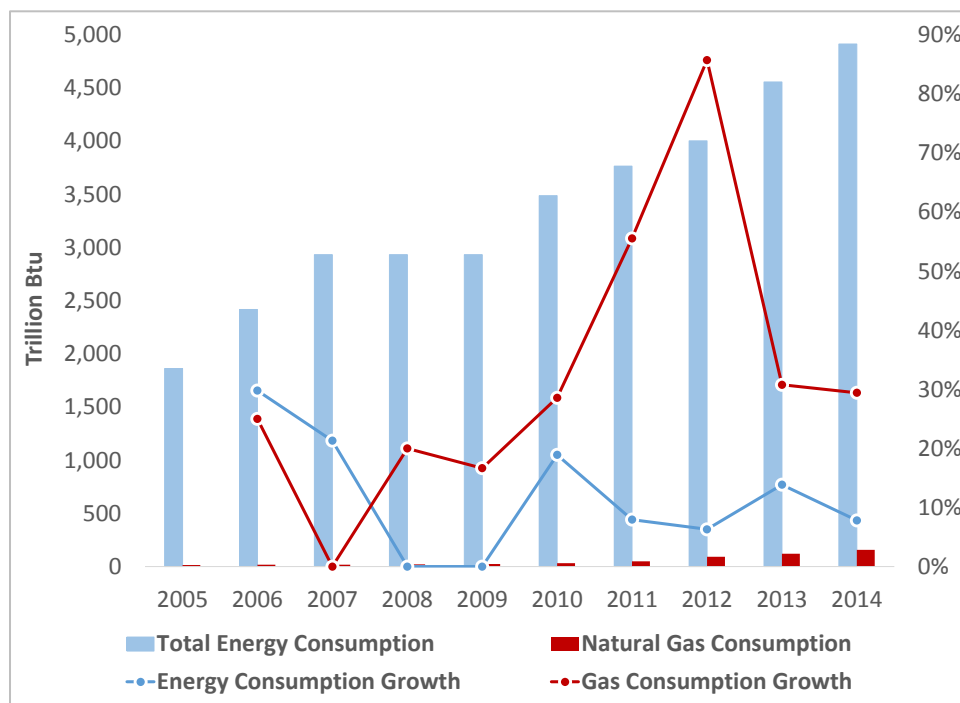


China’s aluminum industry is similar to steel in that it suffers from overcapacity and oversupply of the domestic markets. Domestic demand is weak due to decreased consumption by the real estate and manufacturing sectors. Refined aluminum prices are low and state-owned Aluminum Corp. of China had the biggest net loss of any state owned enterprise in 2014.¹⁵¹ Like steel, this sector too has relied on export growth, 25% on average between 2005 and 2015, to deal with the overcapacity situation (Mukherji et al., 2015b). In international markets, Chinese aluminum exports are viewed like its steel exports: illegal dumping of subsidized production.

Although the industry has closed 3 million tons of aluminum capacity since 2010, it added 17 million tons of new capacity 2010-2015, 4 million tons in 2015 alone (Mukherji et al., 2015b). It is expected to add another 7 million tons in 2016 even though it is not certain that it can be put into operation (Leung, 2016). Like steel the aluminum industry enjoys government subsidies including tax credits and cheap loans.

Total energy use in the non-ferrous metals sector grew at an average annual rate of 11% 2005-2014. Non-ferrous metals sector gas use was 4.3 BCM in 2014 accounting for 4.6% of total industrial gas use and grew at an average rate of 32% 2005-2014. Gas increased its share of total industry energy use from 0.7% in 2005 to about 3% in 2014. Coal is the main competitor to natural gas in the non-ferrous metals sector and coal use grew at an annual average rate of 25% 2005-2014 and increased its share of total sector energy use from 29% in 2005 to 61% in 2014.

Figure 29. Non-Ferrous Metals Sector Use of Gas and Energy in China



Source: NBSC, CEE estimates 2014 and 2015

¹⁵¹ Wildau, 2016.



We think that the aluminum industry in its current configuration is unsustainable and, like steel, will contract over the long term. Rebalancing capacity and production will take time for the same reasons as in the steel industry. The rebalancing is complicated by local government subsidies to smelters to support employment. Electricity accounts for most of the energy consumption in aluminum smelting and local governments have offered off-balance-sheet loans and power subsidies to keep capacity on-line (Mukherji et al., 2015b). Overall, weak profitability in the near term and the likelihood of sector contraction in the longer term renders it unlikely for gas demand in the aluminum sector to grow significantly.

With respect to the total non-ferrous metals sector, gas use is small although it has grown rapidly. Significant total sector gas demand growth is dependent on expansion of the non-aluminum industries and/or coal to gas switching driven by government environmental policies.

Gas Use in Other Industries

The “other industrial” sector accounted for 25% (23 BCM) of total industrial gas use in China in 2014 but is insignificant (2%) in India. The large “other industrial” category in China reflects its larger economy and more diverse gas-consuming industries as well as the wider delivery capacity of its gas infrastructure. The components of the “other industrial” category can be seen in Table 8.

The other industrial category’s gas use grew at an average annual rate of 34% between 2010 and 2014

(

Figure 30) but growth began to slow in 2014. The two largest gas consuming categories (non-metallic minerals (clay, glass, cement) manufacture and wholesale/retail trade) accounted for 75% and 59% of the sector’s gas use in 2010 and 2014, respectively, and grew at an average annual rate of 24% over the period. The remaining categories grew more rapidly as the economy expanded.

Coal is a major competitor for natural gas in the non-metallic minerals, food and beverage, and paper categories: its share of those categories energy use in 2014 was 89%, 63% and over 90%, respectively. It is moderately present in wholesale and retail trade and textiles with market shares of 35% and 25%, respectively. In the remaining categories, the coal market share is 10% or less.

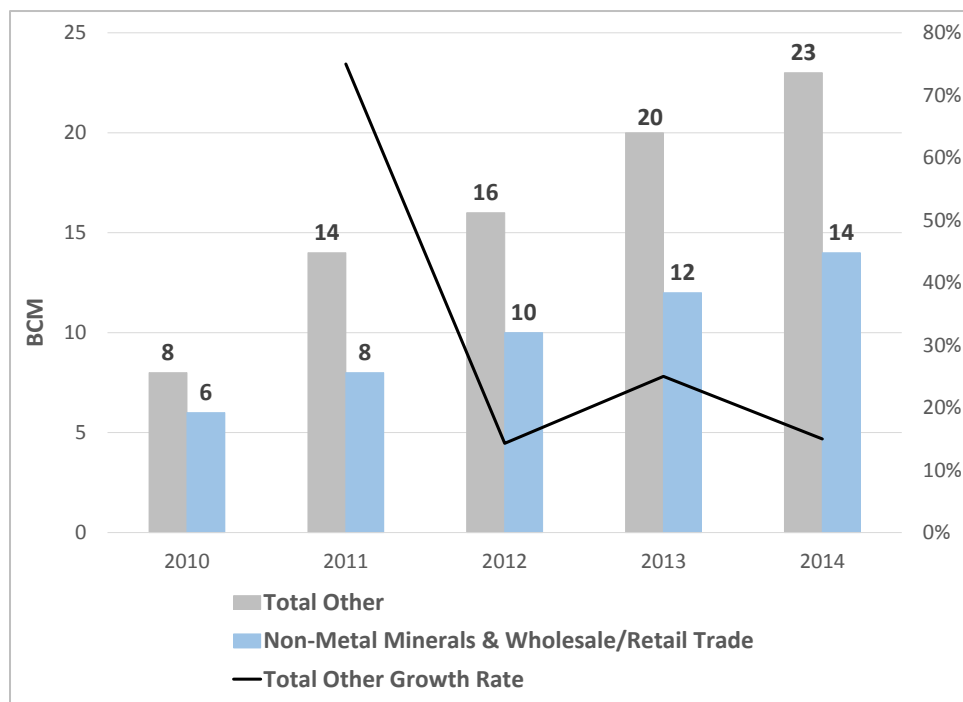
Table 8. Other Industrial Sector Gas Use in China 2014 (BCM)

Other Industrial Sector Category	BCM	Percent of Total
Non-metallic minerals (Clay, glass, cement) manufacture	9.2	39%
Wholesale & retail trade; hotels; restaurants	4.7	20%
Manufacture of transport equipment	2.2	9%
Manufacture of machinery	2.0	8%
Food & beverage manufacture & processing	1.6	7%
Manufacture electronics & electric equipment ¹⁵²	1.4	6%
Manufacture of metal products	1.4	6%
Manufacture of textiles	.6	3%
Manufacture of paper	.6	3%
Total	23	100%

Source: NBSC. Numbers may not add due to rounding.

¹⁵² Includes manufacture of communications equipment and computers.

Figure 30. Other Industries' Use of Gas in China (BCM)



Source: NBSC.

The manufacture of non-metallic minerals category could see slower growth as China transitions to a services-led economy, especially if the construction sector contracts significantly. This category's annual growth rate dropped from 33% in 2013 to 12% in 2014. Manufacture of specialty glass for cars is expected to grow more rapidly than cement going forward. In contrast, the wholesale/retail trade category grew 25% in 2014 compared to flat growth in 2013. This category should continue to grow in a services-led economy. Other consumer-oriented categories such as transport equipment; food & beverage and electronics which accounted for 22% of other industrial sector gas use in 2014 grew at average annual rates of 18%, 35%, and 7%, respectively, between 2010 and 2014. These categories should continue to grow if China successfully transitions to a consumption-led economy.

Fertilizer Sector in India

The fertilizer industry is critical to India's goal of ensuring food security. Most of the phosphorous and potassium based fertilizers are imported; in contrast, 80% of urea fertilizers are produced domestically. India would like to be totally self-sufficient in urea production. Natural gas is the feedstock for 81% of urea capacity and gas use by urea plants increased 8.6% from 14 BCM in 2011 to 15 BCM in 2014. The highest urea plant gas use in recent years was 16 BCM in 2013.¹⁵³ The fertilizer industry accounted for 60% of total industrial gas use in 2014.

Plants using naphtha and fuel oil as feedstocks were required to convert to natural gas by the end of the 2015-16 fiscal year but three naphtha have been allowed to continue operations until there is an

¹⁵³ MOPNG, February 2016.

assured supply of gas.¹⁵⁴ Feedstock switching could add 4 BCM (or 143 trillion Btu) of gas demand to the base of 15-16 BCM.¹⁵⁵

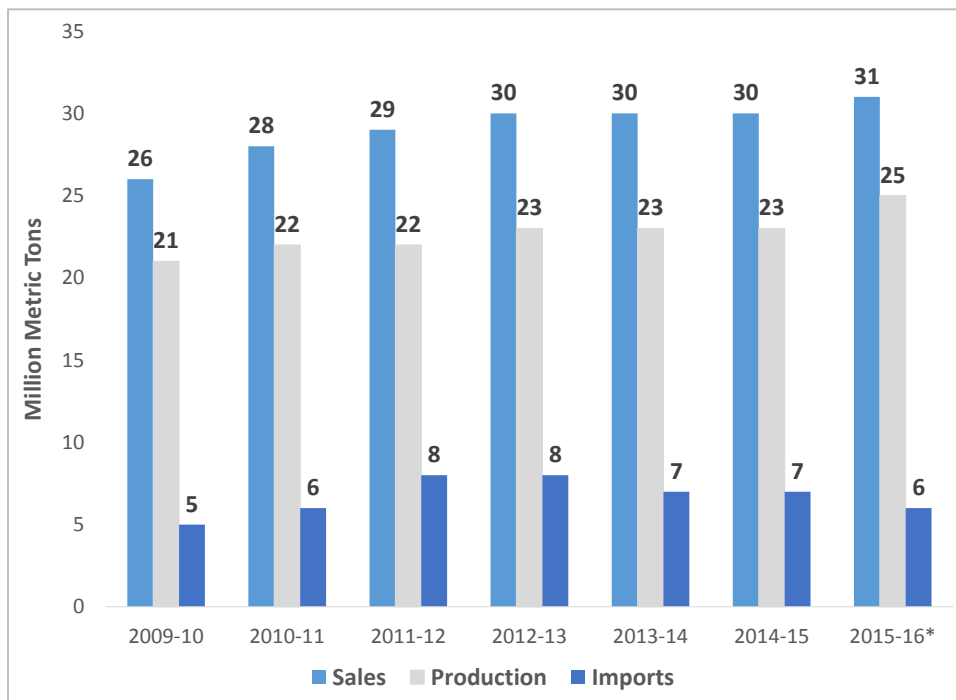
Table 9. Urea Production Capacity by Feedstock

Feedstock	Number of Units	Capacity (100.000 MT)	% Share of Total Capacity
Gas	21	17.1	81%
Naphtha	4	1.9	9%
Fuel Oil	4	2.1	10%
Total	29	21.1	100%

Source: GOI, Report of the Working Group on Fertilizer Industry for the Twelfth Plan. Total capacity of 20 million metric tons reported for 2016-17.¹⁵⁶

The urea fertilizer industry continues to have priority access to domestic gas although it had to consume some LNG as domestic production declined. According to the IEA WEO15 imported LNG met almost one-third of urea plant gas requirements in 2013 at a time when LNG prices were high. Investment in the sector has been very limited due to feedstock unavailability.

Figure 31. Urea Fertilizer Sales, Production and Imports in India



Source: Ministry of Fertilizers; MOF Annual Report 2015-16.

¹⁵⁴ Department of Fertilizers, Fertilizer Annual Report 2015-16.

¹⁵⁵ GOI, Vision 2030 Urea Gas Consumption Assumptions.

¹⁵⁶ GOI, Department of Fertilizers, Ministry of Chemicals & Fertilizers, 2016, Installed Capacity During Reporting Year 2016-17.



Urea production has been relatively flat until 2015-16 and imports have been necessary (Figure 55). Domestic urea production reached a record 24.5 million tonnes in 2015-16 using existing urea capacity.¹⁵⁷ About 50% of imports in 2015-16 were from China.

In 2015 the government approved pooling of LNG and domestic gas prices for urea plants and prices dropped from \$9.00/MMBtu to \$7.50/MMBtu in January 2016 (ICRA 2016 c). The government also approved the revival of three closed urea plants and the construction of the first new urea plant in 15 years.¹⁵⁸ However, securing capital for these projects is a major hurdle and no project had achieved financial closure as of September 2016.¹⁵⁹ India is also exploring coal-based urea production.¹⁶⁰ Overall the pace of new project development in the urea sector is slow.

End-use urea prices to farmers are controlled: the current maximum retail price is about \$87/tonne compared to about \$220/tonne on the world market. World urea prices fell 30-35% in 2015 from \$310-\$320/tonne in December 2014 due to high Chinese exports according to ICRA (2016c). The difference between the cost of production and the maximum retail price is paid to the urea producer. The subsidy covers more than 75% of production costs¹⁶¹ and subsidies paid to domestic urea producers accounted for 26% (\$12 billion) of GOI subsidies in 2012.¹⁶² These subsidies have led to over-consumption of urea by farmers, relative to other price de-controlled fertilizers, which has led to soil chemistry damage. Actual subsidy payments to urea producers significantly lag sales and these huge subsidy arrears (\$8 billion in fiscal 2015)¹⁶³ deters investment in the sector.

In its Vision 2030 projections, the government expects fertilizer sector gas demand to increase from about 16 BCM in 2015-16 to 39 BCM in 2020. Incremental additions are shown in Table 10.

Table 10. Incremental Urea Fertilizer Natural Gas Demand above 16 BCM

Incremental Demand Source	2020-21 (BCM)
Naphtha Switching	3.0
Fuel Oil Switching	1.4
Revival of Closed Plants	4.0
Expansion Projects	6.8
Greenfield Projects	6.7
Revamp Projects	1.0
Total	23.0

Source: Vision 2030

The naphtha and fuel oil switching projects could be delayed by current low prices for those fuels. The expansion, greenfield, and revamp projects require a significant capital outlay in a sector that has not attracted investment in over a decade. These projects do not consider constraints linked to future gas

¹⁵⁷ *The Economic Times*, 2016.

¹⁵⁸ www.dnaindia.com, 12/28/15.

¹⁵⁹ Mikhael and Khemka, 2016.

¹⁶⁰ Ibid.

¹⁶¹ www.dnaindia.com, 12/28/15.

¹⁶² IEA WEO 15.

¹⁶³ Mikhael and Khemka, op. cit.



supplies or gas infrastructure. In the case of rising natural gas prices, there is an implicit assumption that the government would shoulder the additional subsidy burden.

ICRA forecasts that urea sector gas demand will increase from 15 BCM in 2014 to 19, 23 and 26 BCM, respectively, in 2016, 2020 and 2025.¹⁶⁴ As urea plants are currently operating at close to 100% of capacity and the development of new capacity is highly uncertain, we think that projection is high.

At this point, we could see a possible demand increase of around 4 BCM in the near to medium term for the sector if fuel switching actually occurs, but not much beyond that level. We find it difficult to envision significant new investment, even if receiving import parity prices for production, in a sector that requires significant but uncertain government support for its economic viability and that experiences major delays in receiving that support (ICRA, 2016c). The urea subsidy was raised only 1% in the 2016-17 budget and ICRA (2016c) expects delays in subsidy payments to continue.

Considerations for Gas Use in the Industrial Sector in China

Despite its environmental issues, coal is a formidable competitor to gas in the industrial sector. Coal accounted for 72% of Chinese industrial sector energy use in 2014 (up from 62% in 2010) compared to 6% for natural gas. The IEA expects industrial sector coal use to remain flat through 2020 and then declining around 20% by 2040 while industrial gas use increases 32% (30 BCM) between 2014 and 2030. Two of the factors leading to the IEA's projected decline in industrial coal use could also apply to natural gas, e.g. rebalancing of the economy towards services and less energy-intensive industries and improved energy efficiency. In the IEA view, the major driver of growth in industrial gas demand is the enforcement of current pollution and climate policies that require switching from coal to gas that is stronger than that seen to date.

Other forecasters have more bullish views of industrial gas demand growth. Between 2014 and 2030 the EIA and Energy Insights McKinsey expect industrial gas demand to increase by 119 BCM and 64 BCM, respectively. In the EIA Reference Case gas displaces coal in the growing ammonia and methanol industries; the steel industry and its gas use continues to expand moderately; there is strong growth in the gas-consuming non-energy intensive manufacturing industries, and pollution and climate policies promote switching to gas. McKinsey expects significant fuel switching to gas as a consequence of environmental policies and gas demand growth in the chemicals sector to "stabilize."

Focusing on the near term, ICIS sees industrial gas demand increasing by 45 BCM from 2014 to 2020. The chemical sector's share of total industrial gas use will decline from 13% to 9% and the non-chemical industries share will increase from 38% to 40%. ICIS also references coal-to-gas switching as a reason for industrial gas demand growth.

In our view, it is difficult for environmental policies to trump the economic advantages of coal without the imposition of measures that advantage gas economically to coal such as a meaningful carbon tax. It seems unlikely that the government will burden an already slowing economy with a tax that is high enough to trigger the desired fuel switching. The government could rely more upon renewables to meet environmental goals than large-scale industrial fuel-switching, except in the most polluted urban areas. As a result, the pace of industrial fuel-switching to gas may be slower than that envisioned in the forecasts we reviewed. Given the massive investment in coal and methanol-to-olefins technologies, we

¹⁶⁴ ICRA, Gas Utilities Report, 2016.



expect usage of those fuels to grow in the chemicals sector. Naphtha will continue to be the dominant fuel for ethylene production, possibly displacing coal in the near term. We do think gas demand growth will occur in the non-energy-intensive manufacturing industries, especially in those where coal is not a dominant competitor, as the economy becomes more consumer-oriented. However, it is difficult to predict the significance of that growth.

Considerations for Gas Use in the Industrial Sector in India

India's industrial sector is expected to grow as a result of the government-backed push to transition to an industry and investment led economy from a services led economy. Progress in the "Make in India" initiative has been muted to date. Nevertheless, if growth in manufacturing accelerates from current levels, forecasters see significant expansion of the traditional energy-intensive industries like steel, cement, refining and chemicals alongside continued growth in non-energy intensive industries such as textiles, food and beverages, transport equipment and electronics. Growth in the fertilizer industry will be out-paced by other industrial growth.

However, most forecasters see coal as the dominant fuel in the industrial sector. According to the IEA, coal's share of industrial total energy use will expand from 50% currently to 57% by 2040. India's environmental goals and commitments will be met with renewables rather than significant industrial fuel switching from coal to gas. The IEA sees minimal growth in industrial sector gas use of 5-6 BCM by 2030. Growth in gas use in the IEA view is limited by higher gas import prices relative to alternatives, significant limitations in the gas delivery infrastructure and muted growth in domestic gas supplies as a result of pricing mechanisms that discourage upstream investment.

The EIA, McKinsey Energy Insights and ICRA forecast greater increases in industrial gas demand from 2014: 42 BCM and 28 BCM by 2030 per the EIA and McKinsey, respectively. ICRA sees industrial gas demand growing 27 BCM by 2025 with fertilizer gas use dropping from 60% in 2014 to 50% in 2025. These forecasts appear to be predicated on an energy-intensive industrial expansion that will increase the use of all fuels.

Although there could be increased gas demand from the fertilizer industry, we expect the pace of gas demand growth to be slow due to high uncertainty regarding new capacity additions in an industry that requires major government support to survive. With respect to non-fertilizer industrial demand growth, our view is closer to that of the IEA. We think industrial gas demand growth will be muted due to infrastructure and supply impediments; limited duration of current low LNG import prices; limited progress in the push for manufacturing growth to date; constrained access to affordable capital for investment as well as overall impediments to industrial activity.¹⁶⁵

Electric Power Sector

China generated more than four times the amount of electricity generated in India in 2014: 5,811 Twh in China compared to 1,305 Twh in India.¹⁶⁶ Access to electricity is 100% for rural and urban population in

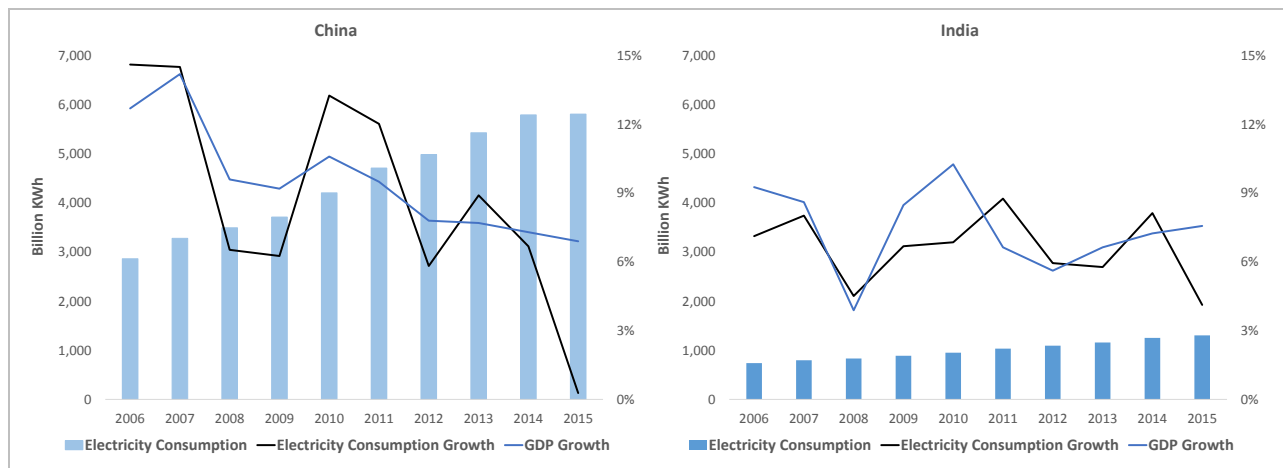
¹⁶⁵ Including, but not limited to, land acquisition difficulties, complex bureaucratic and administrative requirements, time-consuming procedures, local and central government differences, regulatory ambiguity and retroactive taxes.

¹⁶⁶ BP Statistical Review of World Energy 2016.



China compared to 79% (urban) and 70% (rural) in India.¹⁶⁷ The industrial sectors in both countries are the largest and fastest growing electricity consumers accounting for about 76% and 55% of total electricity consumption in China and India, respectively. The agriculture sector plays a much larger role in the Indian economy compared to China and, as a result, agricultural electricity use accounts for about 18% of total use India and less than 1% in China. The annual average growth rate of power generation between 2005 and 2015 was higher in China at 9% compared to 7% for India.¹⁶⁸ However, the power generation growth rate in China has declined from an annual average of 11% (2005-2011) to 5% (2011-2015), with only .3% growth between 2013 and 2014. . In general, electricity consumption and economic growth move together in China (growth rates are correlated at about 0.83). Weaker electricity demand growth reflects the effects of transitioning to a services-led economy. The electricity use of energy-intensive industries decreased by 1.9% in 2015 compared to an increase of 3.7% in 2014.¹⁶⁹ In contrast, the electricity demand of the services sector (tertiary industry) and residential users increased by 7.5% and 5% respectively in 2015. In contrast, electricity consumption growth has been more stable in India with an average growth of about 6.6% between 2006 and 2015, albeit fluctuating along with the GDP growth.

Figure 32. Electricity Consumption and GDP in China and India



Source: BP Statistical Review of World Energy 2016 and World Bank

Electricity consumption is expected to grow in both countries through 2040 as their economies continue to expand but at lower rates than historical rates. Growth in Indian electricity use is expected to outpace that of China’s as India improves population electricity access to 100% and its GDP grows at a faster rate (Table 11; also see discussion in APPENDIX 2).

Table 11. Forecast Average Annual Growth Rates of Electricity Consumption in China and India

Country	EIA (2012-2040)	IEA (2013-2040)
China	2.2%	2.5%
India	3.2%	4.7%

¹⁶⁷ World Bank, World Development Indicators, Electricity production, sources and access, <http://wdi.worldbank.org/table/3.7>.

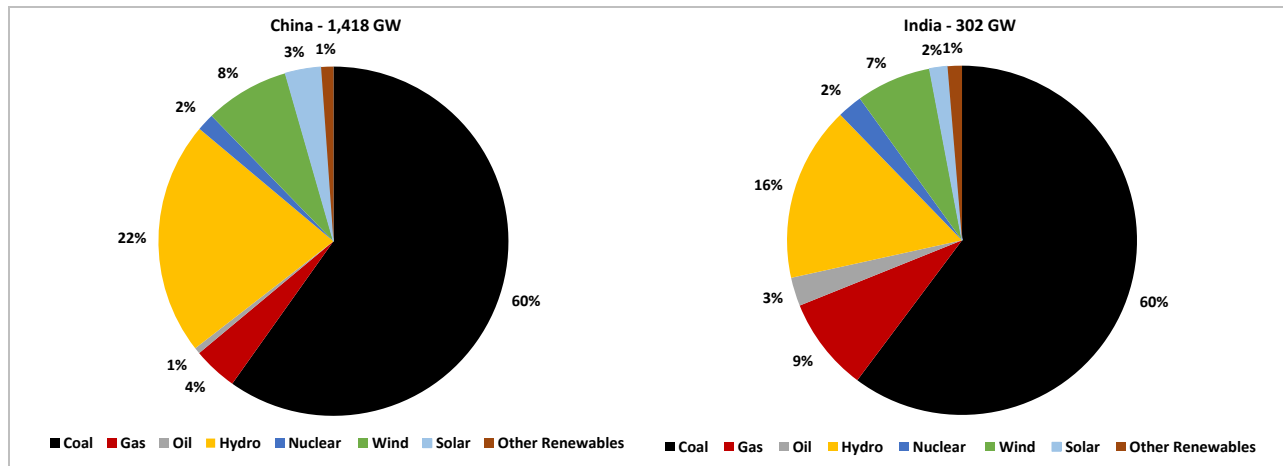
¹⁶⁸ BP Statistical Review of World Energy 2016.

¹⁵⁸ Reuters, 2016, January 17.

Installed Capacity versus Generation

In both countries, coal dominates installed capacity with a 60% share (Figure 33).^{170,171} Only 4% of the installed capacity in China is from gas-fired generation units as compared to 9% in India. Wind has claimed a visible share of installed capacity in both countries with 8% in China (larger than the share of gas) and 7% in India. Solar has also been growing and, in 2015, accounted for 3% of installed capacity in China and 2% in India. Nuclear represents 2% in each country. There currently is overcapacity in Chinese power generation: the utilization rates of all types of generating capacity (thermal, hydro, wind, nuclear) declined in 2014.¹⁷² Coal-fired power plants are estimated to have generated 77% of electricity in India and 71% in China. Gas-fired generation accounted for 2% and 5% of total generation in China and India, respectively, underlining the low utilization of gas plants. Gas-fired generation has been used primarily for peaking in both countries resulting in low capacity factors. Up to 2016, the situation in India has been exacerbated by lack of affordable gas supplies. Power generation gas use accounted for 14% (27 BCM) and 23% (11 BCM) of total gas use in 2014 in China and India, respectively. It is the third largest gas consuming sector in China after residential/commercial gas use which was 18% of total gas use in 2014. It is the second largest gas consuming sector in India after the industrial sector (52% in 2014).

Figure 33. Installed Generation Capacity in China and India, 2015



Source: Energy Information Administration, International Energy Outlook 2016

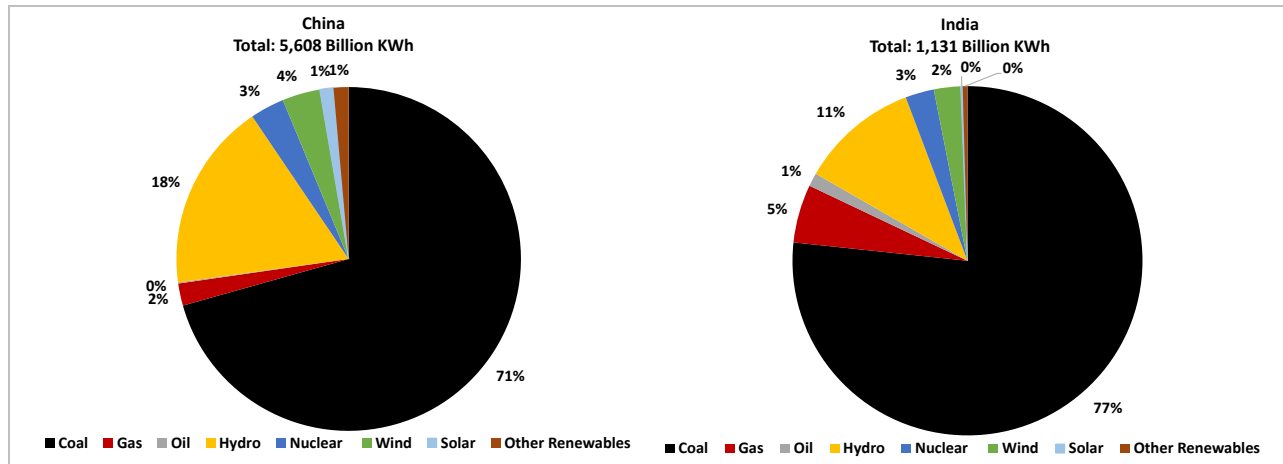
¹⁷⁰ There is significant captive generation capacity in India, which also depends on coal primarily but also has a larger use of natural gas. See Considerations for Gas Use in Power Generation in India for further details on the potential significance of this captive sector.

¹⁷¹ Unlike China, India's coal-fired generation fleet is not of advanced design: 85% use subcritical technology and their efficiency of 35% is below that of China according to IEA (2015). Their poor efficiency is exacerbated by high ash content coal and high ambient temperatures.

¹⁷² Moody's, Inside China, 2/1/16.



Figure 34. Generation by Fuel in India and China, 2015



Source: Energy Information Administration, International Energy Outlook 2016

Most of the forecasts we reviewed expect the largest increases in gas demand between 2014 and 2030 in both China and India to occur in the power sector. Environmental considerations in both countries appear to be the main reason for these expectations as there are impediments to increased gas use in power generation in both countries. Obstacles include the price competitiveness of natural gas with coal and, to a lesser extent, renewables; the limitations of gas infrastructure and domestic gas supplies, and concerns regarding import dependence.

Considerations for Gas Use in Power Generation in China

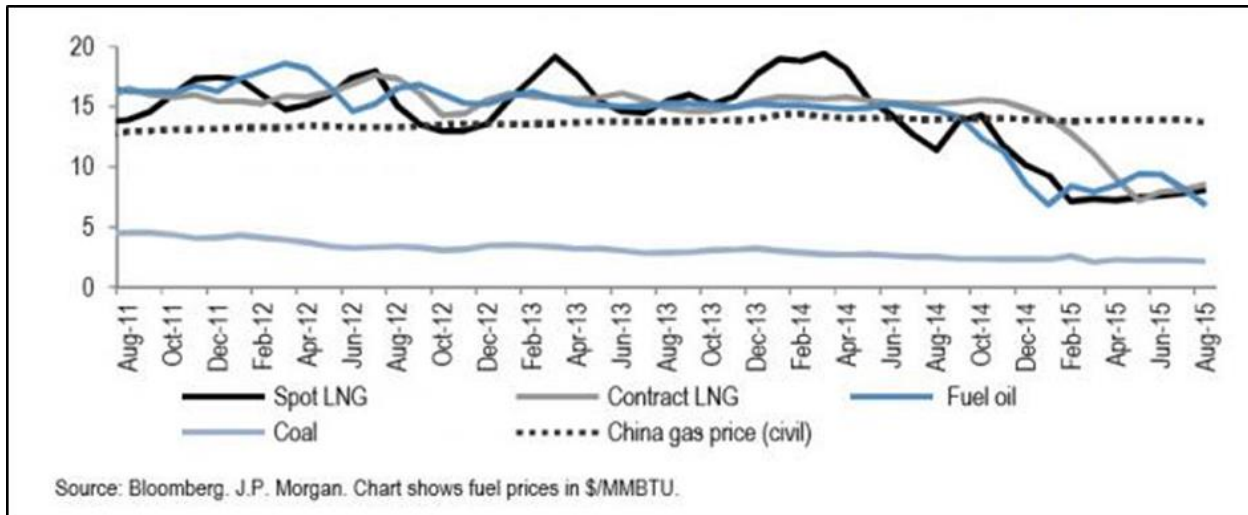
Coal

Domestic and imported coal have been much cheaper than natural gas. Excess capacity in both the Chinese and global coal industries drove global coal prices to very low levels (around \$40/metric ton or \$1.44/MMBtu) over the last five years.¹⁷³ At these price levels, coal has been the cheapest generation fuel (Figure 35). However, 2016 has seen global coal prices rally: In October 2016 the Australian thermal coal price, the benchmark for the Asian market, hit \$100/metric ton (\$3.60/MMBtu) for the first time since 2012.¹⁷⁴ Asian coal prices peaked in 2011 at \$140/metric ton (\$5.04/MMBtu). Even at \$100/metric ton, coal remains very competitive with natural gas. At \$140/metric ton, spot LNG at around \$5.00/MMBtu becomes competitive if there is delivery infrastructure.

¹⁷³ 0.036 metric tons of coal=1 MMBtu.

¹⁷⁴ Hume, 2016.

Figure 35. Prices of Alternative Fuels in Power Generation



Source: Zero Hedge, JP Morgan 16.

The price rally has been attributed to China's effort to reduce the number of smaller high-cost coal mines by putting new coal production caps in place in April 2016. However, China's coal demand continued to rise spurred by 2016 government economic stimulus measures undertaken to increase industrial activity.¹⁷⁵ China's 2Q 2016 domestic coal production decline of 14% was offset by a 17% increase in imports.¹⁷⁶ China has started to loosen the caps on domestic coal production but it has had little impact to date on a market depleted of supply after years of low prices.¹⁷⁷

Longer term China's efforts to limit new coal-fueled plants and India's efforts to increase domestic coal production are expected to act as a check on global coal price increases. BMI Research expects China's domestic coal production to resume growth in 2018 after the significant cuts in 2016 eliminate higher cost producers and coal demand to decrease in 2017 without further economic stimulus measures.¹⁷⁸ Some forecasters like Goldman Sachs think that there is little possibility of a rebound in global coal prices long-term due to a decline in long-term demand that "appears to be irreversible."¹⁷⁹ In a forecast released in October 2016 the World Bank predicted that Australian coal prices would rise to \$60/metric ton (\$2.16/MMBtu) in 2025, averaging \$57.44/metric ton (\$2.07/MMBtu) over the period 2017-2025.¹⁸⁰

China's intentions regarding construction of new coal-fired power plants are unclear. In 2015 permits for 155 new coal-fired power projects were issued after approval authority for power plants was transferred to the provinces (Lelyveld, 2016a). Provinces granted permits seeking construction jobs and expanded tax bases. In April 2016, the NDRC told the provinces to halt plans for 200 new coal-fired plants until after 2017 (those seeking approval and those approved but not yet under construction) and

¹⁷⁵ Goodwill, 2016.

¹⁷⁶ Strumpf, 2016.

¹⁷⁷ Hume, op.cit.

¹⁷⁸ Goodwill, op.cit.

¹⁷⁹ Cunningham, 2016.

¹⁸⁰ World Bank Commodities Price Forecast (nominal US dollars), 2016, October 19, <http://pubdocs.worldbank.org/en/229461476804662086/CMO-October-2016-Forecasts.pdf>.



called for accelerated closing of older, dirtier plants.¹⁸¹ However, the NDRC did not stop 190 GW of new coal-fired power plants under construction.¹⁸² (Greenpeace alleges that 400 GW of new coal plants are in the pipeline.)¹⁸³ Most of the new coal plant construction is being undertaken by the large state-owned generators incentivized by regulated end-use electricity prices that have not fallen in tandem with fuel price decreases.¹⁸⁴ Wind power operators complain of worsening curtailment of their generation due to lack of transmission grid access as the state-owned grid operators favor the projects of the state-owned generators.¹⁸⁵

China also is upgrading its coal-fired generation fleet to improve efficiency and address air quality issues. At least nine large-scale, supercritical coal power bases of advanced design are being developed in western China along with the construction of twelve or more new ultra-high voltage transmission lines from west to east.¹⁸⁶ According to the IEA WEO 2015, 39% of China's coal capacity was considered of supercritical and advanced design compared to 36% in the OECD and 35% worldwide in 2014. In the early 2000s most of China's coal plant additions were of subcritical design but in 2014 China built 85% of the new ultra-supercritical plants added worldwide. By building numerous advanced coal plants and retiring older subcritical plants, China increased its coal fleet efficiency by six percentage points in just ten years.¹⁸⁷ China's average coal-fired plant efficiency is equal to that in OECD countries. The March 2016 13th Five Year Plan calls for any new coal-fired power plants to be "ultra-low emissions" with the goal of making the new plants "as clean as natural gas plants."¹⁸⁸

The government has been directing the replacement of coal-fired boilers in the north with gas-fired combined heat and power (CHP) plants, particularly in the Beijing-Hebei-Tianjin areas which are heavily polluted. These conversions have been largely completed. Paltsev and Zhang (2015) estimated that CHP plants in the Beijing area were losing money on generated power before local government subsidies. Nevertheless, the 13th Five Year Plan calls for the replacement of coal in non-power sectors either with electricity or natural gas.¹⁸⁹ (As noted previously, a services-led economy is more electricity intensive than fossil fuels intensive).

Nuclear

There were 24 nuclear reactors under construction as of mid-2015 and 31 reactors are operational according to the International Atomic Energy Agency. China has also developed a capacity in manufacturing and operations in the nuclear industry that is respected internationally. In its 2016 Outlook for Energy, ExxonMobil expects global demand for nuclear energy to more than double from 2014 to 2040 with China accounting for almost half of this growth. With respect to technological capacity, China is exporting nuclear reactors, power generation units and ultra-high voltage power grids. It added nuclear construction services to the list with China General Nuclear Power's participation in the

¹⁸¹ Forsythe, 2016.

¹⁸² Ibid.

¹⁸³ Wong, 2016.

¹⁸⁴ Forsythe, M., 2016, April 25, op. cit.

¹⁸⁵ Wong, op. cit.

¹⁸⁶ Liu, Z., 2013, Electric power and energy in China, John Wiley & Sons, Singapore.

¹⁸⁷ IEA WEO15.

¹⁸⁸ Seligsohn and Hsu, 2016.

¹⁸⁹ Ibid.



EDF-led troubled Hinkley Point power project in England.¹⁹⁰ There are specific provisions in the 13th Five Year Plan to upgrade China’s nuclear safety apparatus.¹⁹¹

Renewables

Renewable fuels for power generation, especially wind and solar, have been making inroads supported by government policies. Non-hydro renewable generation doubled its share of total electric generation from 2.2% in 2011 to 4.8% in 2015. By comparison, gas-fired generation was 1.7% of total electric generation in 2015. Hydroelectric generation is very significant when rainfall is adequate and accounted for 19% of total electric generation in 2015. Hydro’s share of primary energy consumption grew from 5% in 2005 to 8% in 2015 with Three Gorges commissioned, making China the world’s largest producer of hydroelectricity. China increased its use of non-fossil fuels from 9.4% of primary energy consumption in 2010 to 12% in 2015.¹⁹² The installed capacity of total renewables grew at an average annual rate of 13% between 2010 and 2015 and were responsible for 24% of total power generation in 2015. Wind power has dominated China’s non-hydro renewables mix due to its historical cost-advantage over solar power.¹⁹³ China now accounts for about one-third of the world’s installed wind capacity and is the world’s leading manufacturer of wind turbines. China’s wind energy consumption grew from 1.9 TWh in 2005 to 185.1 TWh in 2015 (BP, 2016). China also has a significant solar manufacturing industry which has vast overcapacity. As a result, “widespread access to cheap components” has lowered costs for solar power developers.¹⁹⁴

Table 12. Renewables Electric Generating Capacity GW

GW	2013 (WEO 15)	2014e (BMI)	2015e (BMI)
Total Non-Hydro Renewables	104.0	158.0	206.0
Bioenergy	9.0	10.0	11.0
Wind	78.0	115.0	145.0 ¹⁹⁵
Solar	17.0	33.0	49.0
Total Electric System Capacity	1,286.0	1,385.0	1,497.0
Total Non-Hydro Renewables % Total	8.1	11.4	13.6
Bioenergy %	0.7	0.7	0.7
Wind %	6.1	8.3	9.7
Solar %	1.3	2.4	3.3

Sources: IEA WEO15, BMI China Renewables Report Q3 2016

¹⁹⁰ Burke, 2016. EDF made its final investment decision on July 28, 2016. However, the same day, in a surprise announcement, the UK announced it wanted additional time to review the David Cameron-approved deal and would make its decision in the early autumn. Prime Minister May, among others, has doubts about the project’s viability. The project has many “non-Chinese” issues, including an electric consumer funded subsidy of 37 billion pounds over 35 years, the troubled EDF design, repeated delays and rising costs. Speculation about political security concerns also surround CGNP’s future construction of a reactor in Bradwell, Essex: “Accepting Chinese money is one thing, letting a Chinese company closely tied to the military know enough about your grid software to connect its reactor to the grid is another.” As of October, 2016, the project appears to be going forward.

¹⁹¹ Seligsohn and Hsu, 2016, March 10, op.cit.

¹⁹² BMI Research, 2016, Q3, China Renewables Report.

¹⁹³ Ibid.

¹⁹⁴ Ibid.

¹⁹⁵ Enerdata, 2016, reported wind capacity of 136 GW as of 5/31/16, an increase of 32% year over year.



Table 13. China Electric Generation from Renewables 2011-2015

TWh	2011	2012	2013	2014	2015
Hydro	699	872	920	1,073	1,126
Non-Hydro Renewables	105	136	195	229	277
Solar	3	6	16	23	39
Wind	70	96	141	160	185
Geo, Biomass, Other	32	34	38	47	53
Total Generation	4,713	4,988	5,432	5,795	5,811
% Hydro	14.8	17.5	16.9	18.5	19.4
% Non-Hydro Renewables	2.2	2.7	3.6	4.0	4.8
% Solar	0.06	0.1	0.3	0.4	0.7
% Wind	1.5	1.9	2.6	2.8	3.2
% Geo, Biomass, Other	0.7	0.7	0.7	0.8	0.9

Source: BP Statistical Review World Energy 2016

The growth of wind and solar power generation has been helped by large decreases in costs. In October 2016, the IEA announced that global generation costs for new onshore wind farms and large solar panel plants fell 30% and 66%, respectively, between 2010 and 2015 and predicts further cost decreases of 15% for wind and 25% for solar over the next five years.¹⁹⁶ The IEA also affirmed that China remains the key growth market for renewables.

Broad frameworks including enabling legislation, policies and wide ranging financial incentives which facilitated the rapid growth of renewables in China contrast with smaller, more incremental measures with respect to gas-fired generation.¹⁹⁷ The IEA stated in 2016 that “strong policy support in China” for renewables will facilitate capacity growth in coming years.¹⁹⁸ The IEA reported that in 2013 China’s subsidies for natural gas totaled \$2.1 billion compared to \$7.3 billion for renewables.¹⁹⁹ BMI Research states that the “government’s strong support for renewable energy is the primary factor underpinning our bullish forecasts for China’s non-hydro renewables capacity over the coming decade.”²⁰⁰

One of the most important frameworks, for example, is the 2005 Renewable Energy Law (REL) which was amended in 2009. It levied a fee on all electricity use and allocated those funds to develop new renewable energy projects. It also requires grid operators to purchase all the electricity produced from renewable sources (Stocking and Dinan, 2015). As in many other jurisdictions around the world, renewables are dispatched first when available, followed by the least expensive thermal source, which is currently coal. Natural gas is last in the dispatch order. In the power reforms released by the NDRC in November 2015 renewable power producers will become “preferred generators” versus coal-fired

¹⁹⁶ IEA, 2016, October 25.

¹⁹⁷ ICIS, 2016, March, ICIS China Gas Market Monthly, Vol III-3 No. 18, page 17. “According to ICIS research, there is no national subsidy or financial support policies for gas-fired power generation at present, and only some local governments have such subsidy policies. However, local governments have cancelled or downsized subsidies under financial pressure after the on-grid tariffs for gas-generated electricity were reduced in November 2015. Hence, natural gas-fired power generation business has been struggling.”

¹⁹⁸ IEA, 2016, October 25, op. cit.

¹⁹⁹ IEA, WEO 2015 Fossil Fuel Subsidies Database,

<http://www.worldenergyoutlook.org/resources/energysubsidies/fossilfuelsubsidydatabase/> and Kavanagh, 2016.

²⁰⁰ BMI Research, 2016, Q3, China Renewables Report, page 11.

plants in proposed electricity trading markets and small-scale solar and wind producers will have guarantees that distribution companies will buy their power.²⁰¹

There are some potentially significant problems associated with China's rapid renewables expansion. Locations with the highest wind power output are mostly in remote western and northern regions whereas the demand centers are in the east. As a result, significant electric transmission and distribution network investment is required. However, actual investment in the electric grid infrastructure has not been sufficient to accommodate all the added wind and, in some cases, solar, capacity. Idling of wind and solar generation due to grid infrastructure issues has been increasing and in the case of wind, idled capacity reached 15% in 2015, a 69% increase from 2014.²⁰² In mid-2016, the National Energy Administration (NEA) estimated that an average of 26% of total wind power generation in China is "wasted" due to limited grid connectivity.²⁰³ In 2016 the NDRC implemented regulations for grid operators in 11 regions where idling has been frequent requiring them to have guaranteed utilization hours for wind and solar power. It is not clear if the guaranteed hours can be accommodated without additional grid investment. In July, 2016 the National Energy Administration (NEA) announced a new risk alerting system to limit or prohibit construction of new onshore wind capacity in regions where insufficient transmission capacity leads to a "waste of generated power." Green, orange and red regions will be designated on a yearly basis. New onshore wind capacity will not be allowed in red regions.²⁰⁴ Wasted wind power generation reaches 33% and almost 50% of total wind generation in some northern and western provinces.²⁰⁵

Reluctance to increase China's electricity costs is another emerging issue. The subsidies for renewable energy are presumably funded by a surcharge to the electric ratepayers. However, the electric bill surcharge has been too low to cover the subsidies. Power tariffs have been increased moderately in the last several years, but apparently not enough to cover the full cost of the subsidies. Local governments control end-user power tariffs and historically have been very reluctant to increase rates. As a result, it is estimated that about \$5-\$6 billion in unpaid subsidies is owed by the government to renewables developers.²⁰⁶ This situation is having a negative impact on the investment sentiment of project developers. In addition, feed-in tariffs for onshore wind and photovoltaic solar were reduced in early 2016 and further reductions are expected for onshore wind in 2017 and 2018.²⁰⁷ The feed-in tariff reduction presumably reflects the falling costs of manufacturing wind turbines and solar panels and related equipment. It would not have a negative impact on project profitability if the other subsidies were paid in full.²⁰⁸

²⁰¹ Aizhu and Rose, 11/30/15.

²⁰² BMI Research, 2016, Q3, China Renewables Report.

²⁰³ Enerdata, 2016.

²⁰⁴ Energy Insights, 2016, August 1.

²⁰⁵ Op.cit., Enerdata, 2016, July 25.

²⁰⁶ BMI Research, 2016, Q3, China Renewables Report. Estimates of the National Center for Climate Change Strategy and International Cooperation.

²⁰⁷ Chinese European Energy News, 2016, 11/1.

²⁰⁸ Moody's, 2016a. The expansion of renewables have been fueled by large subsidies.

Environmental Policies

China does have policies to increase the share of non-fossil fuels in primary energy consumption to 15% by 2020 and 20% by 2030 and to limit the share of coal to less than 62% of primary energy consumption by 2020.²⁰⁹ China also submitted an Intended Nationally Determined Contribution (INDC) as part of the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21) in 2015. The INDC is not legally binding; it is a statement of national intention but includes the following targets: peaking of CO₂ emissions at around 2030 and making best efforts to peak even earlier. Peaking in 2030 would entail lowering emissions per unit of GDP 60-65% from the 2005 level.

According to Kossoy et al. (2015), China has said that a carbon emissions trading scheme (ETS) is necessary for the achievement of their INDC commitment. In 2013-2014 China initiated pilot ETSs in seven regions: Beijing, Guangdong, Shanghai, Shenzhen, Tianjin, Chongqing and Hubei. In 2015 China focused on extending the ETS programs beyond the seven regions. The country plans to launch a nationwide ETS possibly by the end of 2016 and to fully implement it by 2019. The nationwide system would target carbon emissions reductions in the power, iron and steel, chemicals, building materials, cement, paper and nonferrous metals industries.²¹⁰ However, some officials think that the timetable for a nationwide system is too aggressive and that the country should carry on with some expanded pilots for the rest of the decade (Reklev, 2015). Market participants are unhappy with over-allocation, price volatility, low liquidity and a “near complete lack of transparency” in the pilot ETS programs.

Kossoy et al. (2015), among others, report that an average carbon price of between US\$80/tCO₂e and US\$120/tCO₂e by 2030 is consistent with the goal of limiting global warming to two degrees Celsius. China’s national carbon prices in 2017 and 2020 are expected to be in the range of US\$6/tCO₂e and US\$9/tCO₂e, respectively. The cost of carbon in China would have to increase by at least ten-fold from present levels if one follows the above guidelines to achieve the country’s INDC.

In the end, however, our view is that for gas to be competitive in the Chinese power sector, attractive pricing (market based and demand sensitive) and deliverability (supply and enabling infrastructure including storage) will be more important than environmental policy. If gas cannot be competitive in terms of fundamentals, environmental policies are likely to foster growth of alternative fuels and technologies.

Conclusions on Chinese Power Sector Gas Use

All the forecasts we reviewed predict significant growth in electricity demand as the economy continues to expand, albeit at a lower rate, and becomes more services-oriented and electricity intensive. All the forecasts expect the largest increases in China’s gas demand between 2014 and 2030 to come from the power sector. Near term, ICIS expects power sector gas demand to increase by 35 BCM (30%) by 2020. (Table 14; also see discussion in APPENDIX 2).

²⁰⁹ IEA Energy and Climate, June 2015.

²¹⁰ Davies and Westgate, 2016, May 4.



Table 14. Increases in China Power Sector Gas Demand 2014-2030 (BCM)

Power Sector Gas Demand Increases 2014-2030	Gas Demand Increase (BCM)	% Increase from 27 BCM in 2014
IEA NPS	104	285%
IEA CPS	95	252%
EIA Reference	107	298%
Energy Insights McKinsey	172	537%

Sources: Various, as cited elsewhere.

Except for the EIA, the large power sector gas demand increases in all the forecasts rely to varying degrees on the implementation of environmental policies that will limit coal and favor gas use. Timely investment in any necessary gas and power infrastructure required to meet this growth in power sector gas use is assumed to be forthcoming. McKinsey expects an 11% compound annual growth rate in power sector gas use as a result of implementation of a meaningful carbon cap and trade scheme that will disadvantage coal use relative to gas use. McKinsey acknowledges that renewable power generation is a higher priority for the government than gas generation. The IEA notes that the role of gas in power generation is more limited in countries where gas import costs influence domestic gas prices and in those cases gas demand growth in the power sector is sustained by air pollution policies and power mix diversification policies. Per the IEA the most important driver for increased gas use in China is “the need to improve urban air quality” which will require fuel-switching from coal and oil to gas in the industrial and power sectors. The EIA case for increased power sector gas use is different. The EIA expects that growth in renewables and nuclear power generation will allow China to fulfill its INDC to increase the share of non-fossil fuels in the primary energy mix to 20% by 2030. Growth in power sector gas use is spurred by an increase in gas supply sources, including Russian gas supplies via the Power of Siberia pipeline.

We think significant growth in natural gas use in the power sector is problematic, largely because of our view noted above – gas must be able to compete on fundamentals, with market based, demand sensitive pricing for all fuels and dispatched power. Coal should continue to be much cheaper than gas; the need for new coal delivery infrastructure is not as great as it is for gas and coal-fired generation is less reliant on imports than gas-fired generation. A high carbon tax is not only politically unlikely, it will also undermine the competitiveness of natural gas against renewables that are experiencing lower costs, strong government policy support and continuing subsidies. China is also increasing its nuclear capacity significantly and that capacity will supply a large portion of China’s base load generation. Currently there is overcapacity in power generation from all sources with capacity utilization rates at their lowest since 1978.²¹¹

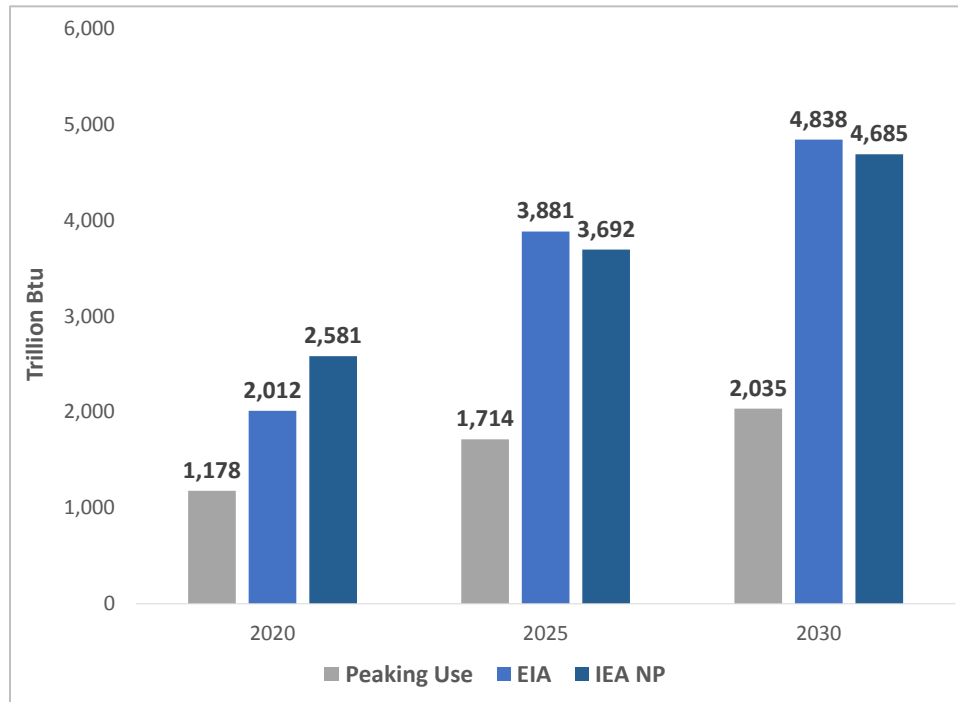
In his 2013 book, Zhenya Liu, the Chairman of the State Grid Corporation of China, one of the world’s largest electric transmission companies, saw gas resources and prices as uncertain compared to coal and would limit gas-fired generation to a peak shaving role (Liu, 2013). He states that natural gas should be used as a household fuel first and secondarily as an industrial fuel. The third use is for peak shaving in electric generation and to accommodate the addition of intermittent wind and solar resources. Based on Liu’s estimates of gas-fired generation capacity (70 GW by 2020; 100 GW by 2030) and assuming a 7,750

²¹¹ Hornby, 2016.



Btu/kWh heat rate²¹² and a 25% capacity factor increasing to 30% in 2025, the “peaking use” natural gas demand would be lower than that of IEA and EIA (Figure 36).

Figure 36. Power Sector Gas Use Scenarios in China



Source: Energy Information Administration International Energy Outlook 2016 (EIA); International Energy Agency World Energy Outlook 2015 New Policies scenario (IEA NP). Peaking Use reflects the CEE scenario

The EIA also estimates 74 GW of gas-fired capacity in 2020. With our heat rate assumption, the capacity factor should be at least 40%, much higher than the recent average of about 30%. For 2030 the EIA estimate of installed gas-fired capacity is much higher at 124 GW, much higher. A capacity factor of at least 57% is necessary to burn 4,838 trillion Btus of gas. If the fleet were to be more efficient in 2030 (e.g., a lower heat rate of 7,000), the capacity factor would have to reach 63%. The IEA anticipates 110 GW in 2020 and 170 GW in 2030, significantly larger estimates than both Liu (2013) and EIA. As such, capacity factors do not have to be as high as those implied by the EIA numbers: about 38% in 2020 and 45% in 2030 would suffice with a heat rate of 7,750. The comparison of forecasts and CEE peaking use scenario (using the capacity estimates of Liu, 2013) demonstrates the wide discrepancies that exist across expectations regarding installed capacity of gas-fired generation and their capacity factors. China’s modern gas-fired power fleet has been utilized mostly for load-following and peaking purposes, leading to a nationwide average of about 30%. Whether more plants will (or, should) be built while existing plants are not fully utilized is a valid question to ask. Whether the utilization rates can be

²¹² This heat rate is less efficient than the average for a modern combined cycle fleet (6,000 to 6,500) but more efficient than most peaking units (9,000 to 10,000). Heat rates will decline if the units are not utilized at high capacity factors and/or owing to hot and humid ambient conditions. As such, this number should be considered a rough average.



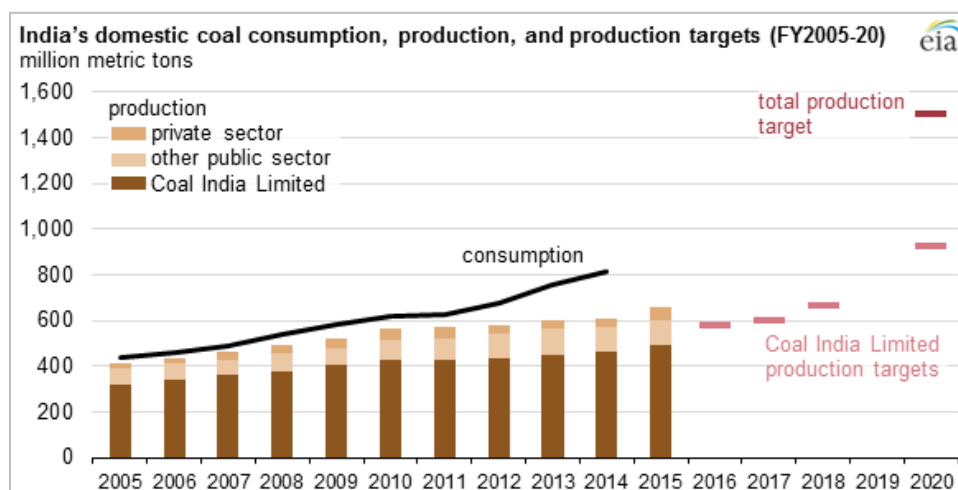
increased with persistent and, in some cases, growing competition from coal, nuclear and renewables is also worth questioning.

Considerations for Gas Use in Power Generation in India

Coal

Like China, India's abundant coal resources offer supply security and low costs if they can be managed properly. The share of imports in total coal consumption in India climbed to almost 26% in 2014 from 7-8% in the mid-2000s. India is planning to increase its coal production from 603 million tonnes in 2013 to 1.5 billion tonnes by 2020 (Figure 37) in order to decrease reliance on more expensive imported coal. The plan also calls for increasing the role of the private sector and public sector producers other than the Coal India Limited, which accounted for about three quarters of production in the past. The target for 2020 is for reducing the share of Coal India Limited to about 60-65%.

Figure 37. Coal Production, Consumption and Targets in India



Source: EIA which used Energy Statistics 2015 by Government of India, Ministry of Statistics and Programme Implementation; Provisional Coal Statistics 2013-14 by Government of India, Ministry of Coal; and news reports.

These targets represent a very ambitious plan for an industry that has been plagued by production shortfalls for many years and whose state-owned companies and labor unions oppose competition. Nevertheless, the government has reformed coal block allocation²¹³ and mine licensing procedures;

²¹³ Coal block allocation refers to the process by which the Indian government allocates coal mines to private and government companies. Prior to March 2015, private companies could have coal mines only for "captive use." Allowed end uses include iron and steel production, power generation, cement production and coal washing. Prior to the enactment of the Coal Mines (Special Provisions) Bill in March, 2015 (CMB15), the Ministry of Coal (MOC) designated a Screening Committee (SC) to provide recommendations on allocations for captive coal mines. The SC made all captive mine allocations to private companies. All other mine allocations to government companies were made by the MOC. Between 1993 and 2011, 218 coal blocks were allocated to private and government companies under this process. In September 2014, the Indian Supreme Court declared the allocations of 204 of the 218 coal mines illegal as they were arbitrary and not based on objective criteria. The CMB15 established an auction process to allocate the 204 coal mines declared illegal as well as other producing and captive coal mines. 74 mines with a specified end-use (captive) were publicly auctioned pursuant to CMB15 by March 31, 2015. The 204 illegal mines as well as future mines can be government allocated to any company awarded a power plant project through competitive bidding or publicly auctioned to any government, private or JV company and the public auction



expanded the scope of private sector participation in the state-dominated sector and accelerated key rail transportation projects.²¹⁴

India's relatively young coal-fired power plant fleet (around 50% of the plants are ten years old or less according to IEA, 2015) will remain the backbone of the baseload power generation system. 85% of today's coal fleet are based on subcritical boiler technology according to the IEA. India may retire inefficient plants early and replace them with larger supercritical plants. New coal-fired power plants are expected to use supercritical technology and the Indian government may make that a mandatory requirement.

Environmental Policies

Similar to China, India's environmental policies affecting the power sector are heavily tilted to the development of non-fossil fuel renewables, especially solar and wind, and development of advanced design coal-fired plants for baseload power. India's intended nationally determined contribution (INDC) to reducing global carbon emissions includes increasing solar power capacity from 5 MW in January 2016 to 100 GW; more than doubling wind power capacity to 60 GW; and increasing nuclear power capacity from 6 GW to 63 GW, all by 2022. Non-fossil fuel power generation capacity will be at least 40% by 2030.

There are many significant challenges to implementing this plan but this is India's current path (CarbonBrief, 2015). Although not explicitly stated, it appears that natural gas' role will be of a balancing nature, essential but limited (e.g., daily load following and peaking, accommodating the addition of intermittent renewables). The price tag for this INDC is very high at an estimated \$2.5 trillion and India says it will need low cost international financial assistance to meet its targets. It is not clear how much India itself is planning to contribute to the investment and how much of the INDC is conditional upon financial aid. This is not a minor issue as raising large sums of investment capital in India is fraught with difficulties. In addition, there are issues related to land acquisition, renewable purchase obligations, and timeliness of implementation and transmission grid expansion, to name a few. There has not been mention of the imposition of significant carbon taxes that would disadvantage coal relative to natural gas. There is currently a tax on coal that partially flows into the National Clean Energy Fund; in the 2016-17 budget, the tax was raised from \$3/tonne to \$6/tonne.²¹⁵

System Reliability and Captive Power

India has had peak day power deficits every year since 2009 and this has led to the rise of captive generation plants. These captive plants are owned by industries that want to protect themselves from power supply shortages. Their generation was equivalent to about 13% of total generation for the fiscal year that ended on 3/31/13.

Although dominated by coal-fired generation, captive plants had a larger percentage of gas-fired generation (16%) than the electric utilities (7% in the year ended 3/31/13). The captive plants tend to be

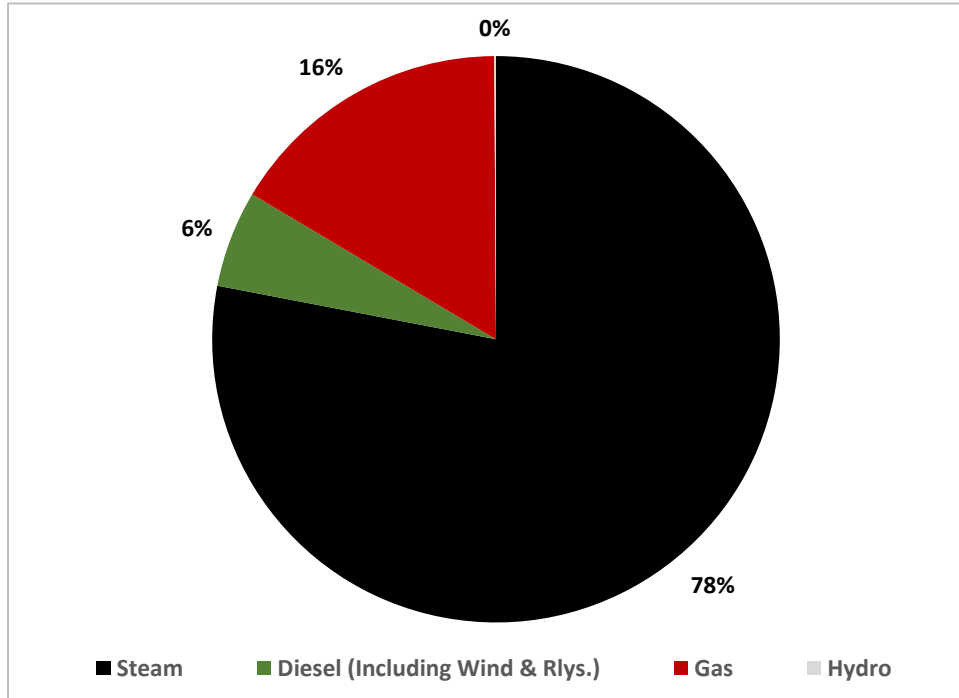
winners can use the coal for any purpose. The goal of CMB15 is to ensure an equitable and transparent distribution of coal mines and to create a fair, level playing field for them. Another goal is to enable private companies to mine coal for any purpose in order to improve the coal supply in the market. PRS Legislative Research, 2015, March 7, Coal Block Allocations and the 2015 Bill, <http://www.prsindia.org/theprsblog/?p=3487>.

²¹⁴ March 2015 Coal Mines Special Provision Bill. EIA 8/25/15.

²¹⁵ Garg, 2016.

inefficient and under-utilized and those that are coal-fired often worsen local air pollution. Industries such as steel, cement, chemicals, sugar, fertilizers and textiles are key owners of captive plants according to IEA (2015).

Figure 38. Captive Power Plant Generation by Fuel in India (148 billion kWh), 2013



Source: Ministry of Power. Data represents industries with more than 1-MW load

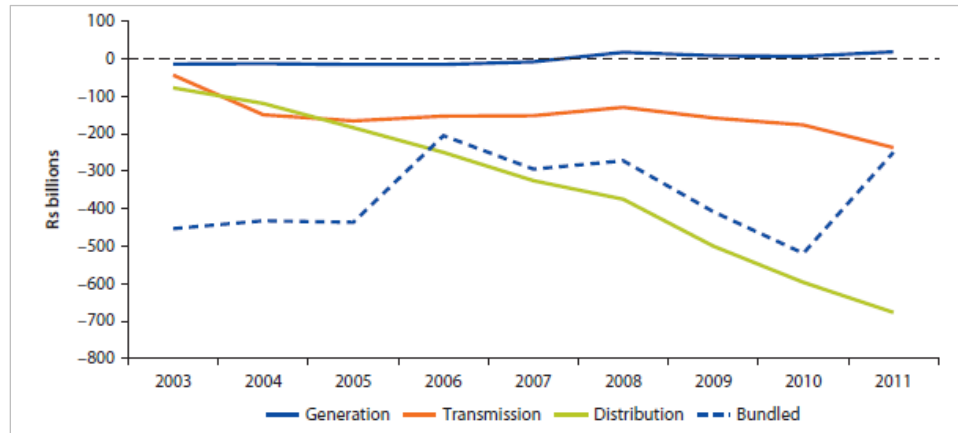
Power Companies Financial Problems

Thermal (coal, oil and gas) generation capacity factors have been declining since 2009 and in 2014 were estimated to be 64% for coal-fired plants and less than 25% for gas-fired plants. Reasons for the low load factors include fuel supply problems in both coal and gas; the overall poor financial condition of India’s electric distribution companies (EDCs), and inadequate expansion of the electric transmission system.

India’s electric distribution companies (EDCs) have been losing money at an increasing rate since 2003 (.). Sector wide accumulated losses (negative equity on the balance sheet where annual after tax profits or losses are recorded) in 2011 were \$25 billion and \$20.3 billion were EDC losses. EDC debt grew at a CAGR of 23% in real terms 2003-2011 and represented \$28 billion or 36% of total power sector debt. By March 2015, EDC accumulated losses reached about \$58 billion with debt of about \$64 billion, bearing 14-15% interest rates.



Figure 39. Accumulated Losses by Power Sector Segment, 2003-2011



Source: World Bank, 2014, *More Power to India*. Bundled includes state electricity boards and power departments.

According to the World Bank, there are three primary drivers of the EDC losses: tariff underpricing, distribution technical and nontechnical (theft) losses, and tariff under collections. In 11 states in 2011 electricity tariffs did not cover costs, including interest, assuming “normal” distribution technical/nontechnical losses of 10%. Average technical/nontechnical distribution losses decreased from 32% in 2003 to 21% in 2011 but remained above the international norm of 10%. The share of revenue collected to revenue billed was 94% in 2011, up slightly from 89% in 2003.²¹⁶

In late 2015, the Modi government implemented a plan to improve the operational and financial performance of EDCs: the UDAY scheme. The scheme has four components: operational efficiency improvements aimed at reducing technical/nontechnical losses to 15%; power cost reductions through the increased supply of cheaper domestic coal; interest cost reductions due to the states taking over 75% of the EDCs’ debt by 2016-17 and the imposition of financial discipline by the states on the EDCs as the states are obligated to fund 50% of future EDC losses. The goal is to achieve EDC profitability by 2018.

As of June, 2016, the Ministry of Power (MOP) reported the following progress on the UDAY scheme (April-June 2016 compared to the same period in 2015): Average power costs paid to generators are down 13%; technical/nontechnical losses and revenue under collections are down significantly in several UDAY states; state assumption of EDC debt is proceeding and 15 states are now participating in the UDAY scheme. The MOP reviews UDAY scheme progress monthly.²¹⁷

Critics observe that similar schemes have failed twice in the last 15 years as “state governments gave away electricity freebies to secure political patronage, discoms (EDCs) obediently picked up the bill on their balance sheets, and banks subserviently financed the discoms.” The jury is still out.²¹⁸

Power Sector Declining Gas Use

The power sector’s natural gas demand decreased sharply in recent years. The most important driver was the decline in production of less expensive domestic natural gas (Figure 40). As a result, the power

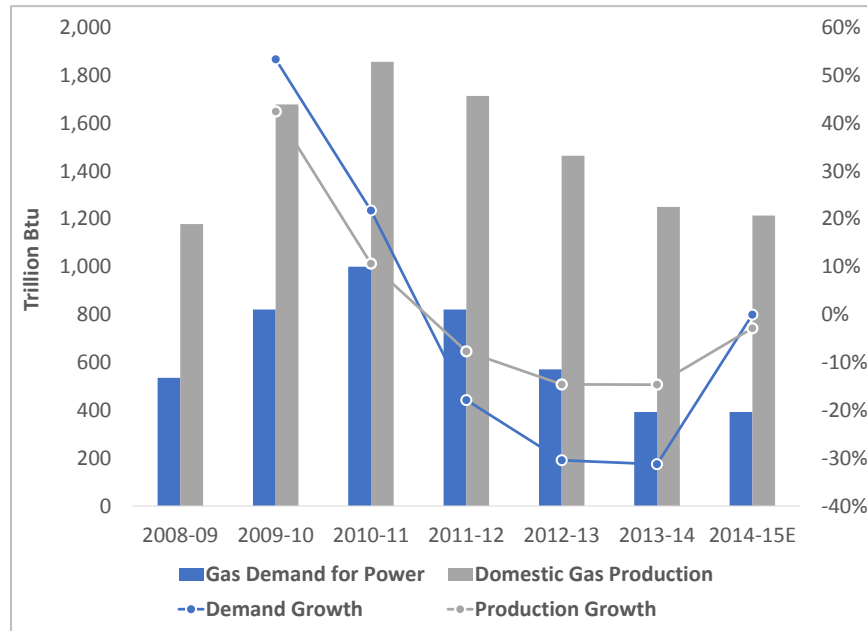
²¹⁶ GOI, 2015, November 5, UDAY.

²¹⁷ Singh, 2016.

²¹⁸ Gopalakrishnan, 2016.

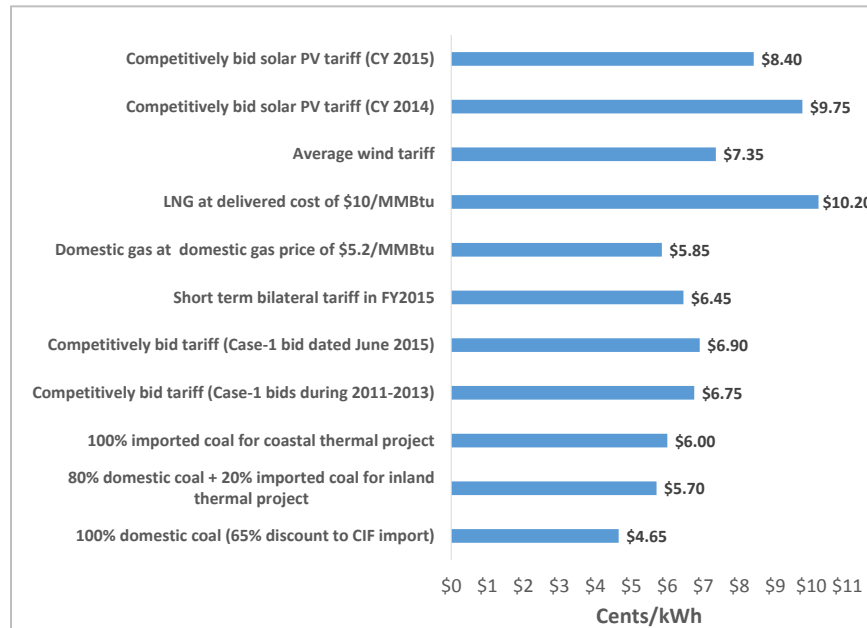
sector was allocated increasing amounts of LNG. Imported LNG prices were significantly higher than domestic prices until 2015-16 (see India gas pricing discussion) and pushed power purchase costs to levels that were unaffordable for financially-stressed EDCs. Even at low prices LNG compete poorly with coal, especially at higher exchange rates (currently around 66 rupees per US\$, Figure 41).

Figure 40. Gas Demand of the Power Sector and Domestic Gas Production in India



Source: Ministry of Petroleum and Natural Gas

Figure 41. Comparison of Overall Cost of Power Gen under Different Fuel-Mix Scenarios in India



Source: ICRA, 2016a. Converted to cents per kWh using an exchange rate of 1.5 cents per rupee.



As a result, 59% of total gas-fired power capacity was completely stranded from April 2014-January 2015 (Table 15). 74% of private gas-fired capacity was stranded as compared to 35% of central government plants and 49% of state government generators.

Table 15. Stranded and Operating Gas-Fired Power Generation Capacity in India, 4/14-1/15

Sector	Central	State	Private	Total
Stranded Capacity (MW)	1,967	2,665	9,673	14,305
Operating Capacity (MW)	3,657	2,759	3,427	9,844
Average Capacity Factor of Operating Units	35%	42%	22%	32%

Source: Ministry of Power

The Indian government funded a potential \$75-billion subsidy scheme (\$35 billion in FY 2016 and \$40 billion in FY 2017 based on \$10/MMBtu LNG) to bring gas-fired generating plants' load factors up to 25-30% in order to manage continuing peak day power deficits. Generators bidding the lowest needed subsidy below a cap would be allocated LNG.

Investors in the natural gas value chain had to make sacrifices: regasification and pipeline transport charges were reduced by 50% and marketing fees were reduced by 75%. The sales revenue from the program could only be used for operating and maintenance costs and debt service. No return on equity was permitted. Banks holding current and potentially non-performing loans of up to \$16 billion on these power plants were "encouraged to negotiate debt relief within Reserve Bank of India guidelines." The first two phases of the program allocated LNG to 42-50% of the 24 GW of under-utilized capacity.²¹⁹ Due to decreased LNG import prices, the government was able to discontinue subsidies in CY 2016.

Conclusions on Indian Power Sector Gas Use

The forecasts we reviewed project significant growth in power sector gas demand although not as large as the projected increases in Chinese power sector demand (excluding the GOI Vision 2030). ICRA predicts an increase in demand from 11 BCM in 2014 to 39 BCM in 2016, with demand remaining flat at 39 BCM between 2016 and 2025.

Table 16. Increases in Indian Power Sector Gas Demand, 2014-2030 (BCM)

Forecast	Gas demand increase over 11 BCM in 2014	2030 demand/2014 demand of 11 BCM (%)
IEA NPS	38	344%
IEA CPS	43	391%
EIA Reference	11	104%
McKinsey	21	191%
Vision 2030	118	1073%

Sources: Various, as cited elsewhere.

The IEA does not expect gas-fired generation to produce baseload power in India. Instead gas-fired plants will perform a peaking/load balancing role which is essential in reducing the large peak day deficits and will drive the increase in sector gas demand. Per the IEA, gas's share of power sector energy consumption will increase from 5% in 2013 to 9% by 2040. Coal will remain the dominant fuel in the

²¹⁹ GOI, Ministry of Power, Office Memorandum No.4/2/2015-Th-I. Also Press Trust of India, 2016.



power sector although its share of total fuel use drops from 79% in 2013 to 66% in 2040. Renewables' share of total fuel use will increase from 10% in 2013 to 16% in 2040, driven by a six-fold increase in non-hydro renewables fuel use. The share for nuclear will triple from 3% to 9%.

McKinsey expects that the Indian government will impose carbon taxes that will favor gas and allow displacement of coal in the power sector. The EIA has a more conservative view of power sector gas demand. In the EIA case, renewables and nuclear fuel most of total energy demand growth in the power sector between 2012 and 2040. Gas' share of total sector fuel use decreases slightly from 6% in 2012 to 5% in 2040 and coal's share drops from 76% in 2012 to 56% in 2040.

If low LNG prices persist, we think power sector demand will increase enough to have adequate utilization of existing gas-fired generation capacity. However, given the limitations of India's gas infrastructure natural gas is not likely to play a baseload power role in the future or increase its share in total generation significantly. Given the uncertainties surrounding potential increases in domestic gas production, and the inability of the sector to tolerate high LNG prices (e.g., the inability of EDCs to charge electric rates high enough to cover costs), our outlook for power sector demand is on the low end of the forecasts (Table 16). Solving fundamental problems of price reform and infrastructure development could take years. It is worth noting that the EIA lowered its projections for electricity sector gas use in India significantly from the 2013 edition of the International Energy Outlook in the latest edition in 2016.

Table 17. Gas Consumption by Indian Electric Sector in IEO13 and IEO16 (Quad Btu)

	2020	2025	2030
IEO 13	1.1	1.2	1.4
IEO 16	0.4	0.5	0.8

Source: EIA IEO 13 and IEO 14

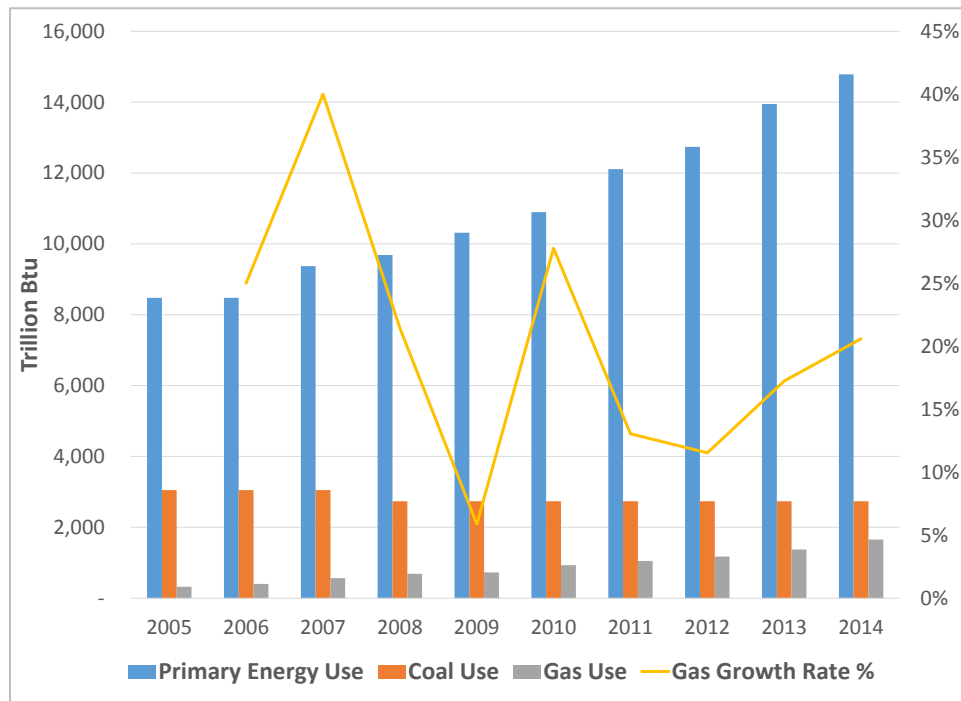
Key developments to monitor include (1) the relative prices of LNG and coal; (2) gas infrastructure expansion; (3) growth in domestic gas supplies (3) the implementation of the renewables program, including the availability of financial aid; (4) domestic coal production levels and (5) the overall financial condition of the electric distribution sector.

Residential/Commercial (Households): China

Overall household energy demand grew at an average annual rate of 7% 2005-2014. In 2005 coal accounted for 38% of household total energy consumption dropping to 19% in 2014. In northern China using coal to heat homes and offices is a common practice and coal demand has been remarkably persistent at 53 BCM. Natural gas' market share increased from 4% to 9% over the same period growing at an average annual rate of 18% to 34 BCM in 2014 (Figure 42). In southern China the main use of gas is for cooking, water heating and summer air conditioning; in northern China the primary gas use is for space heating. Northern China gas demand exceeds that of the south. The residential/commercial sector was the second largest gas consuming sector after the industrial sector in 2014.



Figure 42. Household Energy Demand in China (MMTOE)



Source: NBSC

The growth in residential gas use was driven by rising urbanization, rising consumer incomes, efforts to reduce air pollution and the cross-subsidization embedded in the gas pricing regime which keeps residential rates low at the expense of industry, power generators and the transport sector. All of these growth drivers are expected to stimulate sector gas demand in the future albeit at a lower rate. Urban areas consumed 98% of household gas in 2012 and China's urbanization rate is expected to increase from 55% at the end of 2014 to 67% by 2030.²²⁰ Residential gas consumers have priority in the NDRC gas allocation plan.

A plethora of city gas distribution (CGD) companies have been established, many owned or associated with central and/or provincial government entities, which has enabled the rapid development of the pipeline network. These companies have targeted areas which are economically more developed and densely populated (coastal areas) as well as areas with rich reserves of natural gas (western areas).²²¹ The sales growth of these companies has been 20%+ through 2014 although some analysts are forecasting future growth rates in the mid to low teens.

Growth in residential/commercial sector gas use requires further expansion of gas distribution systems as well as associated infrastructure. Twenty-two of China's 31 regions have household gas access rates of less than 40% resulting in great potential for further market penetration. Around 32% of medium and large size cities in China have access to gas pipelines. Expansion of gas storage capacity will be necessary to accommodate seasonal swings in this sector's gas demand.

²²⁰ OIES, November 2015.

²²¹ Fitch Ratings, 7/17/15.



The residential sector is very price sensitive: a 1% price increase is estimated to decrease consumption by 3%.²²² Residential users were shielded from the major gas price increases in 2013 through 2015. As of mid-2015 gas was competitive with the non-coal alternate fuels. LPG, which also competes with gas in the residential sector, is now lower than the residential gas price on a wholesale basis although further decreases are prevented by the price floor. The NDRC is just beginning to allocate additional costs to the residential sector via a three-tier volume pricing scheme which, in the near term, will affect only 10% of households. (See discussion in pricing section).

Table 18. Residential Fuel Prices, July 2015 (\$/MMBtu)

Fuel Type	\$/MMBtu
Natural gas	11.40
Electricity	25.40
LPG	25.00

Source: S. Paltsev and D. Zhang, 2015

All the forecasts we reviewed expect residential/commercial sector gas use to triple from 34 BCM in 2014 to around 70-80 BCM in 2030. To realize this growth potential, we think that continued reform of residential gas pricing and expansion of gas infrastructure, especially storage, are required. Absent a carbon tax or similar economic penalties, we think it could be difficult to displace much of the persistent 53 BCM in coal use.

Key developments to monitor include: (1) the urbanization rate; (2) CGD infrastructure expansion and sales growth; (3) NDRC efforts to increase residential gas prices and actions on the pricing of competing fuels and (4) imposition of carbon costs on residential coal use.

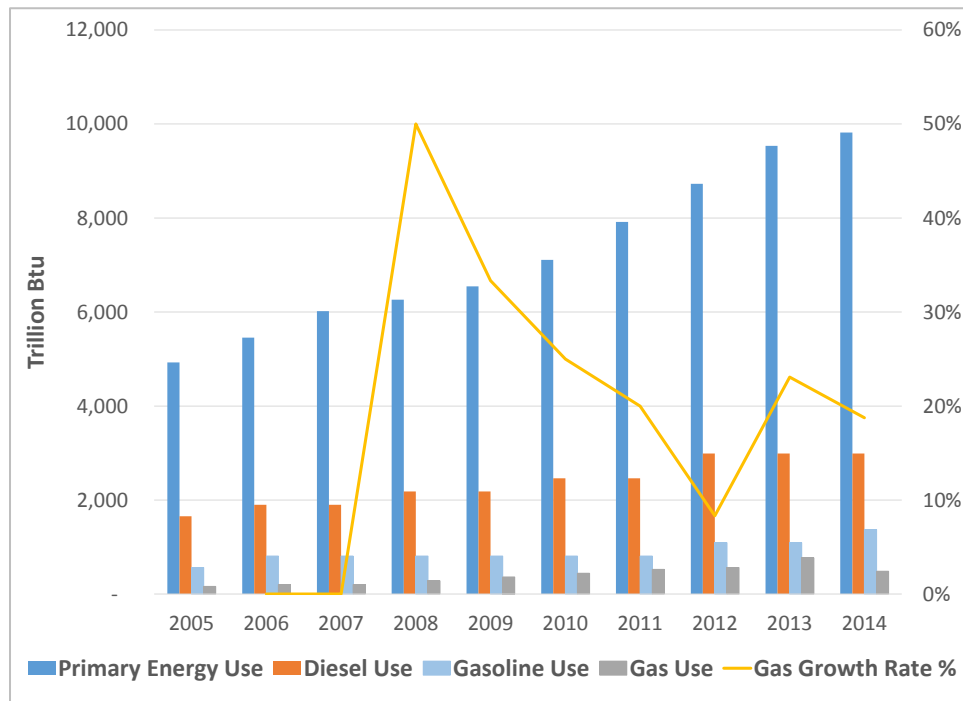
Transport Sector - China

Natural gas use in the transport sector (road vehicles, railway, air and marine) represented 11% (21 BCM) of China's total gas use. Transport sector natural gas use grew at an average annual rate of 21% from 2005 to 2014 which outpaced the growth rates of diesel (7%), gasoline (12%) and overall primary energy (8%). There is a structural change beginning to take place in vehicle fuel demand. Diesel's share of total transport energy use declined from a high of 35% in 2010 to 31% in 2014. In contrast, the shares of gasoline and natural gas increased from 11% and 3%, respectively, in 2005 to 14% and 8%, respectively, in 2014. The drop in diesel demand is attributed to slower economic growth, greater fuel efficiency in heavy duty vehicles and competition from NGVs. Growth in gasoline demand is a result of high light duty car sales. Higher priced gasoline is the main competitor to natural gas in the passenger car market.

²²² Wang, et. al., 2014.



Figure 43. Natural Gas Use in China Transportation



Source: NBSC

China's NGV (natural gas vehicle) fleet has grown from 693,000 in 2004 to about 4.5 million at the end of 2015²²³ served by 7,000 NGV refueling stations.²²⁴ Most vehicles run on CNG (compressed natural gas). Supported by infrastructure subsidies from the government and CGD companies, there has been rapid growth in CNG refueling stations. 80% of the NGV fleets are in the gas abundant northwestern provinces with 12% in the large coastal cities. There are also about 250,000 heavy duty vehicles operating on LNG on China's roads.²²⁵

The transport sector is the one area in which the Chinese government has actively promoted natural gas use. The government provided the initial subsidies to build up the NGV refueling infrastructure; private investment in the sector was given additional government support. Production of natural gas vehicles peaked in 2013, mostly built by Chinese manufacturers. In recent years, the focus has turned to heavy duty vehicles such as LNG-fueled trucks and CNG/LNG-fueled buses. Some companies have plans to build more than 1000 LNG stations in the next five years.²²⁶ Some industry analysts think that increased sales of CNG and LNG for vehicles is the primary growth driver for city gas distribution companies.²²⁷

Pricing policies have also favored natural gas. The consumption tax (CT) on diesel and gasoline has been much higher than the CT on natural gas since 2009 in an effort to reduce air pollution. There have been

²²³ Stratias Advisors, 2016, March 17.

²²⁴ NGVA Europe, 7/8/15.

²²⁵ Ibid.

²²⁶ NGVA Europe, July 2015.

²²⁷ Kim Eng, 3/26/14.



reports in January 2016 that the government is planning to raise the CT on oil products again.²²⁸

Although retail prices for transport natural gas are higher than prices for any other consuming sector, ICIS reported in March 2016 that the average CNG retail price in 25 major Chinese cities was 64% of the average gasoline prices in those cities, from a high of 93% in southeastern Guangzhou to a low of 29% in western Xining. ICIS noted that CNG prices remained high in cities without access to piped gas supplies such as those in northeast China and coastal regions in south China, underlining the need for expansion of gas distribution systems and associated infrastructure.²²⁹

Of all the natural gas demand forecasts we reviewed, McKinsey and EIA had the most aggressive estimates of transport sector gas demand in 2030 of 63 BCM and 45 BCM, respectively, citing strong government support for gas for environmental reasons. The EIA predicts gas use to increase significantly in large trucks and buses.

We think that significant growth in transport sector gas use is most dependent on the capital-intensive expansion of the refueling stations network and expansion of the piped gas distribution infrastructure. Continuing government support; tax policies that favor gas and expansion of the gas-fueled truck and buses fleets would help turn potential demand to realizable demand.

City Gas Distribution and the Residential and Transport Sectors: India

The city gas distribution sector (CGD) in India (which includes residential, commercial and transport categories) was much smaller (5 BCM) in 2014 than the comparable residential/commercial (34 BCM) and transport (21 BCM) sectors in China. This large difference in market size can be explained by the following factors:

- (1) urbanization, which facilitates development of CGD systems, is more advanced in China (55%) than in India (30%);
- (2) there is a significant residential/commercial space heating market in China that does not exist in India;
- (3) electric units dominate the growing air conditioning market in India and the smaller, seasonal water heating market;
- (4) more than 70% of Indian household energy use is for cooking and solid biomass accounts for about 85% and 25% of rural and urban cooking fuel, respectively;²³⁰
- (5) in urban areas, subsidized LPG is the cooking fuel that is displacing kerosene and biomass;
- (6) diesel, which was subsidized until 2014, accounted for 70% of total transport oil demand;²³¹
- (7) declining supplies of inexpensive domestic gas and high prices for imported LNG until 2015-2016; and
- (8) fragmented gas infrastructure and much less investment in CGD systems in India than China.

India's first CGD company was established in 1972 in Gujarat state. A handful of companies were established in the 1980s and 1990s but the real growth of CGD companies didn't occur until post-2005. Currently 44 cities and towns in India are covered by CGD networks²³² with close to 3 million customers

²²⁸ Lelyveld, M., 1/2/16.

²²⁹ ICIS China Gas Market Monthly, China Gas Price Pool, March 2016.

²³⁰ IEA WEO 15.

²³¹ Ibid.

²³² Saikia, 4/13/15.



(Table 19). Gujarat state accounts for the majority of CGD customers: 49%, 74% and 65% of residential, commercial and industrial customers, respectively, are located in Gujarat.

Table 19. Piped Natural Gas Customers by State, City, Company and Consumer Type

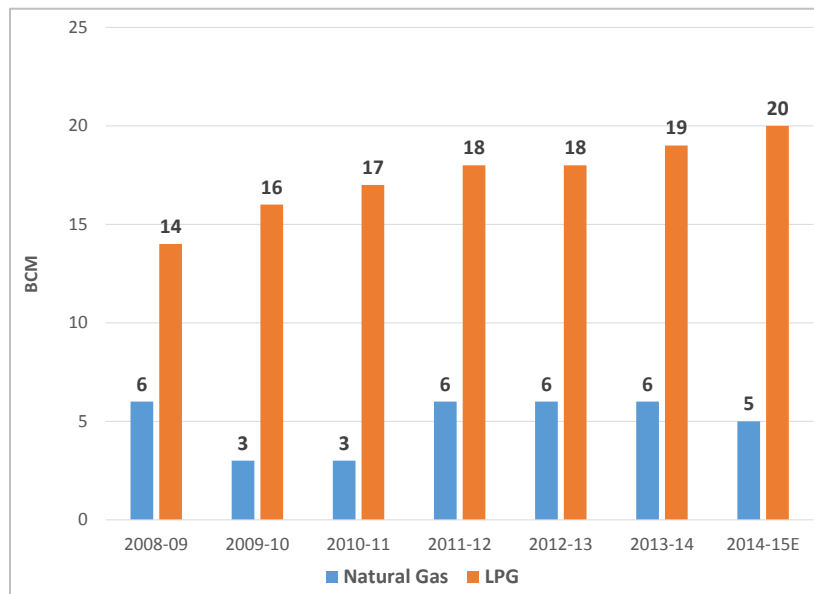
State	City Covered	Company	Domestic PNG	Comm. PNG	Ind. PNG
Delhi	Delhi, Noida, Greater Noida, Ghaziabad.	IGL	560752	1560	726
Maharashtra	Mumbai, Thane, Mira-Bhayandar, Navi Mumbai, Pune, Kalyan, Ambernath, Panvel, Bhiwandi	MGL, MNGL	817468	2654	154
Gujrat.	Ahemedabad, Baroda, Surat, Ankeleshwar	GSPC, SABARMATI GAS, GUJRAT GAS, HPCL, VMSS, ADANI GAS	1392657	16496	3869
Uttar Pradesh	Agra, Kanpur, Bareilly, Lucknow,	Green Gas Ltd. (Lucknow), CUGL(Kanpur)	22559	187	464
Tripura	Agartala	TNGCL	17996	294	47
Madhya Pradesh	Dewas, Indore, Ujjain, Gwalior	GAIL GAS, AGL	3278	34	75
Rajasthan	Kota	GAIL GAS	189	1	18
Assam	Tinsukia, Dibrugarh, Sibsagar, Jorhat	ASSAM GAS CO. LTD	28050	991	377
Andhra Pradesh	Kakinada, Hyderabad, Vijaywada, Rajamundry	BGL	3163	46	3
Haryana	Sonepat, Gurgaon, Faridabad	GAIL GAS, ADANI GAS, HARYANA CITY GAS	23236	93	185
Total			2869348	22356	5918

Source : CGD Companies & PPAC

Source: PNGRB

Indian CGD companies have significant competition from subsidized LPG: the LPG market is four times the size of the CGD market (Figure 44). This competition was eased somewhat as CGD residential customers were allocated more inexpensive domestic gas supplies, a result of their improved Tier 1, status and the LPG subsidy was discontinued for higher income customers. As a result, by December 2015 piped natural gas was competitive with subsidized LPG and 33% cheaper than unsubsidized LPG.²³³

Figure 44. India City Gas Distribution Gas Demand vs. LPG (BCM)



Source: MOPNG. CGD Gas Demand includes volumes for piped natural gas consumers and CNG for vehicles.

²³³ ICRA, December 2015.

Geographical areas for CGD networks are auctioned by the PNGRB. There have been six rounds of auctions. The results of the fifth round auctions conducted in early 2015 were disappointing: eight of the 20 areas received no bids and four areas received only one bid each. Interest in future CGD bidding rounds is expected to grow as a result of the price decreases for LNG and mandatory government decrees to convert some vehicles to natural gas (see transport sector).²³⁴

Growth in CGD networks could be constrained by overly aggressive bidding practices. ICRA has been concerned that bidders are bidding near zero tariff rates and posting large bank-guaranteed performance bonds that substantially exceed the net worth of the bidding entities.²³⁵ The Minimum Work Programs (required pipeline construction and PNG connections) demanded by the PNGRB in the early years are substantial (15% of the five year work commitment is in the first year) and slippage could cause draws on the performance bonds. ICRA thinks that there is a high probability of delays in work implementation due to the high amount of initial clearances and multiple approvals required from various civic and governmental agencies. In addition, the acquisition of rights of way and rights of usage are extremely time consuming.

India had slightly over 2.5 million CNG vehicles on the road in 2015 compared to 4.5 million in China.²³⁶ India had about 1,000 refueling stations compared to over 7,000 in China.²³⁷

Table 20. CNG Activities as of 3/31/15

State	State	No. of Companies	CNG Sales (TMT)			No. of CNG Stations	No. of CNG Vehicles (in Lakhs)
			2012-13	2013-14	2014-15 (P)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GAIL Gas/ Adani Energy/ Gujrat Gas, GSPC, GGCL, SGL, HPCL	Gujarat	7	441.80	463.50	475.90	349	996280
Indraprastha Gas (IGL) New Delhi	Delhi	1	695.10	697.60	717.10	326	773210
GAIL Gas	Rajasthan (Kota)	1	0.80	1.60	2.60	211	500666
Mahanagar Gas Ltd.(MGL) Mumbai, MNGL Pune.	Maharashtra	3	425.10	476.00	531.40	33	31692
Bhagyanagar Gas Ltd.(BGL) Hyderabad.	Andhra Pradesh	1	24.70	24.60	25.80	3	4000
Green Gas Ltd. (Lucknow), CUGL(Kanpur)	Uttar Pradesh	4	137.70	162.60	184.80	40	92592
Tripura Natural Gas Co. Ltd.(TNGCL) Agartala.	Tripura	1	4.30	6.80	9.50	5	6936
Avantika Gas (Indore) / GAIL Gas Ltd.	Madhya Pradesh	2	14.50	15.90	16.60	20	20255
Ltd.	Haryana	3	73.20	78.20	72.30	16	122070
GEECL	West Bengal	1	0.60	1.15	1.24	7	2275
Total		19*	1817.80	1927.95	2037.24	1010	2549976

Source: MOPNG

India's CNG consumption has been growing at about 6% per year in recent years (Table 19) but needs considerably more infrastructure for the sector to take off. The decontrol of gasoline and diesel prices has been positive for the sector until the recent drop in those prices. The Indian Supreme Court gave the sector a boost when in late 2015 it mandated that all Delhi taxis must convert to CNG and registration of new diesel vehicles in the city will no longer be allowed. If similar measures are enacted in other heavily polluted cities, it would encourage sector growth.

Of the forecasts we reviewed, McKinsey had the most aggressive outlook for gas demand in the CGD sector with gas demand increasing from 5 BCM in 2014 to 28 BCM in 2030; their 2030 demand estimate

²³⁴ Ibid.

²³⁵ Ibid.

²³⁶ Stratas Advisors, March 17, 2016, op.cit.

²³⁷ Ibid.



is close to the GOI Vision 2030 estimate of 31 BCM. McKinsey expects most of the demand growth to occur in the residential/commercial sector (23 of the 28 BCM) as a result of favorable government reforms which prioritize household gas consumption over gas use in other sectors. Per McKinsey, growth in transport sector gas demand is constrained by severe competition from lower price oil products. The EIA forecasts 25 BCM of CGD gas use in 2030 but, unlike McKinsey, most of the growth occurs in the transport sector which accounts for 17 BCM of the 25 BCM. The IEA expects more modest growth in CGD gas demand with gas use increasing to 11 BCM in 2030, with 7 BCM in the residential/commercial sector. The IEA expects diesel to continue dominating transport sector fuel use and residential/commercial gas demand growth to be tempered by competition from alternatives.

We think the largest impediments to robust CGD gas demand growth are:

- (1) the large capital requirements to expand an infrastructure that is considerably less developed than China's;
- (2) the dominant role of electricity in the growing air conditioning market; and
- (3) the difficulty of displacing biomass for cooking in rural areas.

Key developments to monitor going forward include:

- (1) the growth of CGD infrastructure;
- (2) the expansion of the refueling station network for both CNG and LNG;
- (3) the availability of affordable natural gas supplies; and
- (4) government subsidy policies for alternative fuels.

NATURAL GAS AND ENERGY SECURITY

There are a number of security issues affecting the natural gas systems in both China and India including security of affordable gas supplies; security of international gas shipping and pipeline transportation routes; the security and adequacy of domestic gas system infrastructure and the ability of the natural gas system to accommodate demand fluctuations.

As both countries are importers of significant natural gas volumes, international gas supply and transportation security are important concerns. The current gas import infrastructures of both countries (pipeline and LND) are shown in APPENDIX 1 - MAPS and Table 21 below. Both countries have attempted to address these security issues, with varying degrees of success, by increasing domestic gas production; expanding and diversifying international gas suppliers; expanding and diversifying transport options; building redundancy in import terminals and increasing global gas supplies through upstream investment in other countries. To date, China has a more expansive and diversified gas import structure than India possibly reflecting India's lack of financial resources and the serious difficulties in building significant infrastructure in that country. China has had more success in increasing domestic gas production than India but significant gas imports are expected to continue in both countries in the foreseeable future. The upstream gas sectors in both countries suffer from disincentives to investment, particularly around pricing, that are discussed in the body of this paper.

The governments of both countries have encouraged upstream oil and gas investment in foreign countries as a way to protect against price volatility and supply shortages. China has been more aggressive in this arena than India, frequently outbidding Indian investors. As of 2014, a total of ten Chinese companies owned production entitlements in 42 countries, of which about half were located in



the Middle East and Africa.²³⁸ Between 2011 and 2013, Chinese companies invested about \$73 billion in global upstream assets.²³⁹ In contrast, ONGC Videsh, the international upstream arm of ONGC and the largest international investor, had 37 oil and gas assets in 17 countries as of March 2015, representing an investment of \$7 billion.²⁴⁰ To enhance the international competitiveness of India’s oil and gas companies, the government has been considering the merger of 13 state-controlled oil and gas companies since mid-2016.²⁴¹

Currently China and India do not have sufficient gas storage to help them respond to supply and demand disruptions. This is of special concern in China which has a growing residential heating market with significant seasonal demand swings: the residential and commercial sector was the second largest gas consuming sector after the industrial sector in 2014. In its 2016 report on global gas security, the IEA noted the importance of gas storage in increasing the security of a country’s gas network.²⁴² Neither country appears to have large potential underground storage. LNG tank storage can offer some relief but it is costly and more suited to covering short-term supply disruptions.

Table 21. China and India Gas Supply and Import Infrastructure

Indicator	China	India
Domestic Gas Production Growth Rate 2005-2015	13.5%	1%
2015 Gas Imports BCM/Percent of Total Gas Supply	59/30%	22/43%
Percent Pipeline Gas Imports 2015	58%	0%
Percent LNG Imports 2015	42%	100%
# Origin Countries of Contracted LNG Supplies 2017/2021 ²⁴³	6/7	4/4
Dominant LNG Supplier Percent of Total Contracted Supply 2017/2021 ²⁴⁴	Australia 40/37%	Qatar 68/35%
# Operational LNG Regasification Terminals/Average Load Factor	12/51% in 2014	4/77% ten months 2015-16
# LNG Regasification Terminals/Expansions Under Construction October 2016 ²⁴⁵	10	2
# Operational International Gas Pipelines/Gas Supply Countries/Average Load Factor 2014	2: Central Asia Gas Pipeline/Turkmenistan/55% and China Myanmar Pipeline/Myanmar/28%	0

²³⁸ IEA, 2014.

²³⁹ Ibid.

²⁴⁰ Verma, N., 2015.

²⁴¹ Stacey, K., 2017.

²⁴² IEA, 2016, Global Gas Security Review.

²⁴³ Ibid.

²⁴⁴ Ibid. The IEA reports that “portfolio players” (LNG aggregators with multiple sources of supply) will play an increasing role in both China and India’s contracted LNG supply portfolio growing from about 22% in 2017 to about 28% in 2021 in China and from 20% to about 33% in India over the same time period. India will rely less on Qatari LNG imports as volumes from the US ramp up from about 3% of total contracted LNG supplies in 2017 to 27% in 2021.

²⁴⁵ Ibid.



Indicator	China	India
# Planned International Gas Pipelines/Gas Supply Countries	1: Power of Siberia/Russia-Delayed	2: Turkmenistan-Afghanistan-Pakistan-India (TAPI) Pipeline/Turkmenistan-Feasibility Studies and \$25 billion pipeline/Russia-In Studies
Gas Storage	7.4 BCM working gas storage; LNG tank storage associated with distribution company liquefaction 32 BCM	Negligible

There has been discussion about the relative riskiness of gas imports by pipeline versus gas imports via LNG. In its 2016 report on Global Gas Security the IEA noted that there is little volume flexibility in global LNG liquefaction infrastructure as it operates as baseload facilities. More troubling the IEA reported that LNG liquefaction capacity unavailable to the market increased from 8% (30 BCM) of total liquefaction capacity in 2011 to 14% (65 BCM) in 2016. Over the period 2011 to 2016, 76% of liquefaction capacity unavailability was attributable to lack of feedstock gas.²⁴⁶

With respect to LNG transportation routes, both countries depend on sea lines of communication (SLOCs): the Straits of Malacca and Hormuz, the Indian Ocean and the South China Sea. China's National Security Law of 2015 requires the state to construct and maintain strategic channels for the transportation of natural resources and energy and to protect their security.²⁴⁷ Both India and China are undertaking ambitious naval modernization programs in part to protect their energy SLOCs.²⁴⁸ China's military presence in the Indian Ocean has increased considerably in recent years and India is concerned that China may challenge India's goal of "being the primary security guarantor in the Indian Ocean."²⁴⁹

It has been reported that some Chinese policy makers favor oil and gas imports by land from Central Asia, Russia and even Iran in order to lessen China's reliance on seaborne energy which is exposed to interference from the US Navy that controls shipping lanes around the Straits of Malacca and Hormuz, the Indian Ocean and the South China Sea.²⁵⁰ Some observers view China's Silk Road strategy ("One Belt, One Road") as China's non-military solution to US global naval dominance.²⁵¹ Others argue that land routes for oil and gas imports will be more expensive and more vulnerable to physical attack by terrorists. Whether by land or sea, it is clear that both India and China are determined to protect their energy trade routes and that objective will continue to be a part of their foreign policies.

The governments of both countries have policies supporting the development of non-fossil fuel energy sources for power generation, especially wind, solar and nuclear. Although energy security may not be the primary driver of these policies and mitigating reliability could be a challenge, wind, solar and nuclear are domestically-controlled resources and do not have the security disadvantages associated with imports. In China, non-hydro renewable generation doubled its share of total electric generation from 2.2% in 2011 to 4.8% in 2015. By comparison, gas-fired generation was 1.7% of total electric

²⁴⁶ Ibid.

²⁴⁷ China Law Translate, 2015.

²⁴⁸ O'Rourke, R., 2016 and Southerland, M., Koch-Weser, I. and Zhang, A., 2014.

²⁴⁹ Southerland, et.al., 2014.

²⁵⁰ Shea, D.C., 2014.

²⁵¹ Tata, S., 2017.



generation in 2015. China has the largest construction program of new nuclear power generation units in the world and has developed a domestic manufacturing industry to support it. China has also developed large wind turbine and solar panel manufacturing industries that allow the country to control a large portion of the supply chain. India is planning for non-fossil fuel (wind, solar and nuclear) power generation capacity to be 40% of total generation capacity by 2030.

SUMMARY AND CONCLUSIONS

We expect growth in industrial energy demand in China to slow as it struggles with massive overcapacity in the energy intensive industries. The uncertainty surrounding the ultimate success of the “Make in India” initiative clouds the prospect of robust industrial energy demand growth in India. The continuation of current low domestic gas and LNG prices could result in short-term demand increases in both China and India but we think continuation of current price levels is not likely over the longer-term. We expect cheap and abundant coal to continue dominating the energy use of the price-sensitive industrial and power sectors in both China and India absent the imposition of a meaningful carbon tax which we think is unlikely. We expect natural gas to play a peaking and load balancing role in both countries’ power sectors with baseload generation coming from nuclear and supercritical, clean coal plants. We think there will be continued strong policy support for renewables in power generation to achieve environmental goals. As a result, our expectation of natural gas demand growth in those two sectors is at the lower end of the forecasts we reviewed. If there are difficulties in accommodating renewables in power sector transmission grids, there may be a possibility for gas to play a greater role in generation.

In our view, there is gas demand growth potential in the city gas distribution sector of China which could be realized if there is continued strong investment in the expansion of distribution and transport infrastructure. We expect more modest growth in the gas demand from this sector in India given the large infrastructure challenges, slower urbanization and the competition from alternatives.

Although India’s population is forecast to exceed China’s around 2022²⁵² and its GDP growth is expected to outpace China’s in the medium term, we think, consistent with the forecasts we reviewed, that India’s gas market will still be about one-quarter the size of China’s gas market in the foreseeable future.

For both countries, natural gas will be most attractive with enabling infrastructure, including storage; flexible supply sources; and transparent, market based, demand sensitive pricing. This last condition applies not only to natural gas but also to other, competing fuels and technologies (and is a condition that underlies natural gas attractiveness worldwide). Environmental policies will not assure growth in natural gas use. In all likelihood, they would mainly serve to foster alternative energy approaches.

²⁵² The Globalist, 2015.



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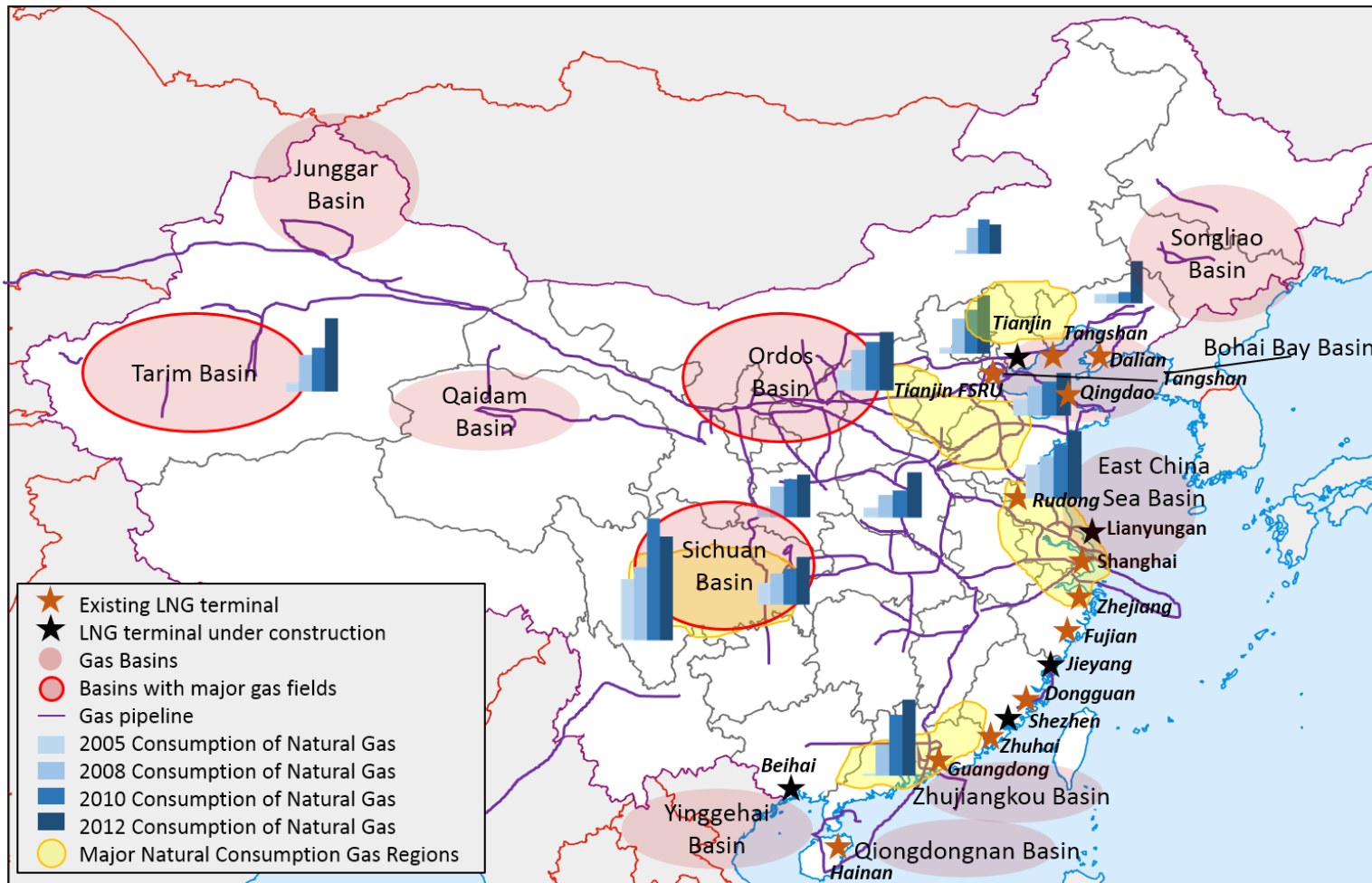


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APPENDIX 1 - MAPS

The following maps provide details on locations of domestic natural gas supply and consumption and key infrastructure components.

Figure 45. Map of China Natural Gas Features



Gas consumption (in bcm) by region during 2005–2012. The vertical bars for each province are provided for illustrative purposes. They can be compared to the represented 2012 consumption of 15 bcm in Sichuan and 10 bcm in Xinjiang. Data Source: NBS (2014b).

Figure 46. China's Natural Gas and Electric Power Value Chain

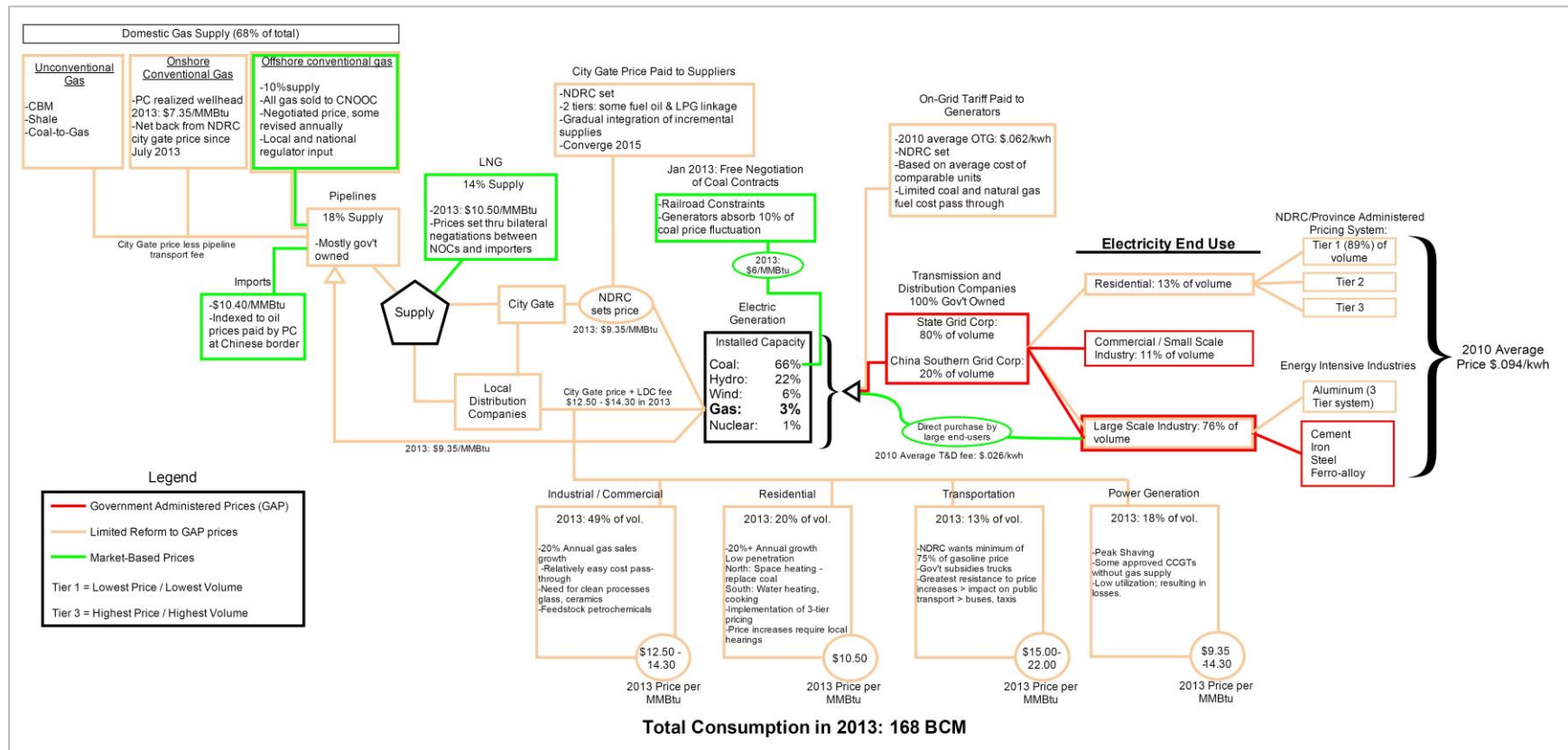
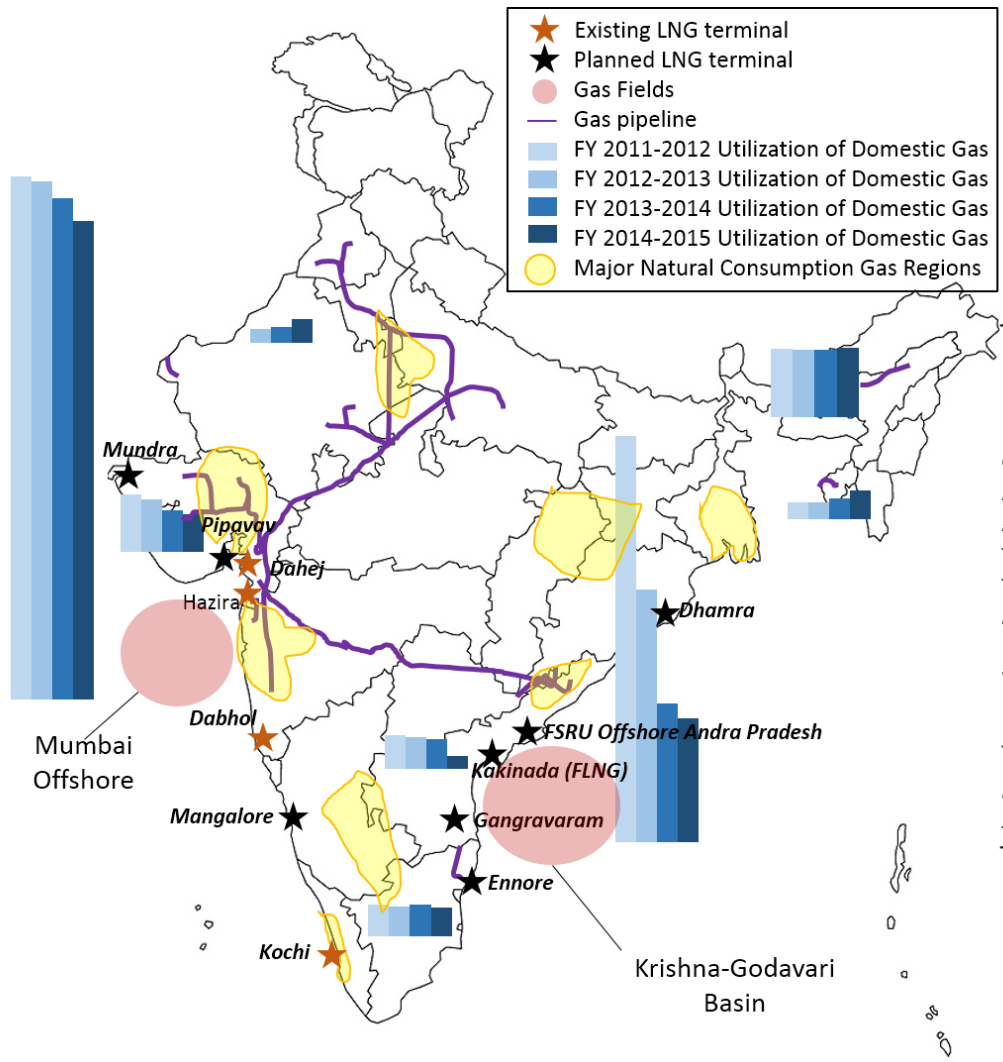


Figure 47. Map of India Natural Gas Features



State-wise Utilization of Domestic Natural Gas in India

	2011 to 2012	2012 to 2013	2013 to 2014	2014 to 2015*
Gujarat (Includes Offshore)	2,315	2,135	1,696	1,514
Assam	2,736	2,716	2,695	2,772
Arunachal Pradesh	14	14	8	9
Tripura	644	647	816	1,140
Tamil Nadu	1,277	1,199	1,298	1,175
Andhra Pradesh	1,362	1,246	1,168	519
Rajasthan	557	634	920	1,080
West Bengal	69	96	141	203
Madhya Pradesh	1	1	2	1
Jharkhand	4	3	3	2
Eastern Offshore	16,394	10,184	5,611	4,991
Western Offshore	21,111	20,902	20,215	19,280
Total	46,481	39,777	34,574	32,685

*Provisional
Figures in MMSCM

APPENDIX 2 – HISTORICAL AND FORECAST DATA

IMPLICATIONS FOR AND FROM OUR RESEARCH FOR OUTLOOKS

In order to understand the drivers of future natural gas demand in China and India we analyzed historical gas use by consuming sector end use: industrial/manufacturing by industry; electric power; residential/commercial; and transport. Our analysis was complicated by sector consumption categorization differences among data reporters (NBSC in China and MOPNG in India; U.S. EIA and the IEA both use Chinese and Indian government data but with definitional changes). These variations in category and definition in turn lead to differences and anomalies in forecast data. The major dissimilarities lie in reported gas consumption by the industrial sector, a key gas consumer in both countries. We revised the reported historical categorizations for this sector as detailed below in order to make the historical consumption data more comparable among reporters and to gain insights into the gas use by the major individual industrial segments. Although there are data differences among reporters with respect to gas use by the other consuming sectors, these are not as significant as the differences in the industrial gas use data. Thus, we did not revise those estimates nor did we revise reported country natural gas use data.

Having made adjustments to reported historical categorizations of the industrial sector for both countries, what can we say about industrial demand in China and India? The industrial sector is the largest gas consumer in both countries accounting for 50% (China) and 52% (India) of total 2014 gas use. However, coal is a formidable competitor to gas in the industrial sectors of both countries accounting for 72% (China) and 50% (India) of total sector energy use in 2014.

The composition of the two countries' gas-consuming industrial sectors are quite different. In 2014 China's chemicals industry accounted for 34% of total industrial gas use followed by "other industrial" (25%); energy sector use for oil and gas extraction (17%); refining (15%); steel (5%); and non-ferrous metals (4%). China's "other industrial" category includes non-metallic minerals and non-energy intensive manufacturing businesses such as wholesale and retail trade, electronics, transport equipment and metals manufacturing, among others. As China transitions to a services-led economy, energy use (including gas use) in the energy-intensive chemicals, refining, steel, non-ferrous metals and non-metallic minerals industries could decrease, especially given that these industries are burdened with massive overcapacity, a point emphasized in our analysis. The chemicals segment is expected to grow but gas use there is limited by the growth in coal and methanol-to-olefins technologies. These decreases in energy-intensive industrial gas demand could be offset, to some degree, by gas demand growth in the non-energy intensive manufacturing (although it is difficult to predict the pace and extent of that growth). Erosion of demand for natural gas with efficiency improvements in Chinese industry could also be supplanted by gas use for electric power generation, achieving overall net growth in natural gas consumption. The preceding analysis sections detail the challenges for gas in that sector.

In India industrial sector gas consumption is dominated by the urea fertilizer industry at 61% of total sector gas use in 2014. The agriculture sector is still very important to the Indian economy and employs over 50% of the eligible voting population. India has a goal of self-sufficiency in urea production and the government thus far has been willing to support the industry with large subsidies. However, growth in fertilizer gas use is problematic due high uncertainty regarding new capacity additions in an industry that needs major subsidy support to survive.

The Indian fertilizer sector is followed by the refining and petrochemical sectors at 19% and 12%, respectively, of total industrial gas use. If growth in energy-intensive manufacturing accelerates from current levels, total industrial sector energy use could increase. However, new capacity in the refining and petrochemical industries is unlikely in the near term limiting gas demand growth. In addition, as in China, gas use is expected to be tempered by growth in industrial sector coal use.

Discrepancies in Historical Data Series

Timeliness and transparency of energy data is an ongoing challenge in research and decision making. Neither one of these large emerging markets, nor many others, much less smaller countries produces and sustains clear and reliable data streams on many measures that could be of great benefit to researchers, planners, investors, suppliers and customers. In recent years, some improvements to data transparency have been made largely as a result of encouragement or outright pressure from multilateral organizations and capital markets. The Joint Organization Data Initiative (JODI) has provided an umbrella for numerous entities to report on oil and gas supply and use with consistent definitions. The JODI effort has yielded the most definitive results for oil and oil products. Data streams on natural gas and especially electric power remain pitifully short of what is needed. Our observations and findings in this paper point to a number of concerns about how natural gas supply and demand are widely interpreted to be evolving in China and India. It is challenging even in the most developed markets to parse natural gas and electric power systems across myriad and highly interconnected segments. Without better, more open information, not only on energy value chains and costs but also on underlying economic structures and performance, we can have little confidence in conventional understandings and established views about energy systems in crucial markets.

On a total gas consumption basis, the historical Chinese data reported by the NBSC, the BP Statistical Review of World Energy, and the EIA are fairly consistent. The IEA is about 9% lower than the others. The historical Indian total gas consumption data is reasonably consistent among all reporters.

Table 22. China Total Gas Consumption

(BCM)	2010	2011	2012	2013	2014	2015
NBSC	107	131	146	171	186	NA
BP SR 16	111	137	151	172	188	197
IEA WEO 15 Gas Balance	98	122	137	156		
EIA IEO 16		137	148			

Sources: NBSC, BP SR 16, IEA WEO 15 Gas Balance, EIA IEO 16.

Table 23. India Total Gas Consumption

(BCM)	2011	2012	2013	2014	2015
MOPNG	61	54	49	47	
BP SR 16	62	58	50	51	51
IEA WEO 15 Gas Balance	61	54	49		
EIA IEO 16	67	62			

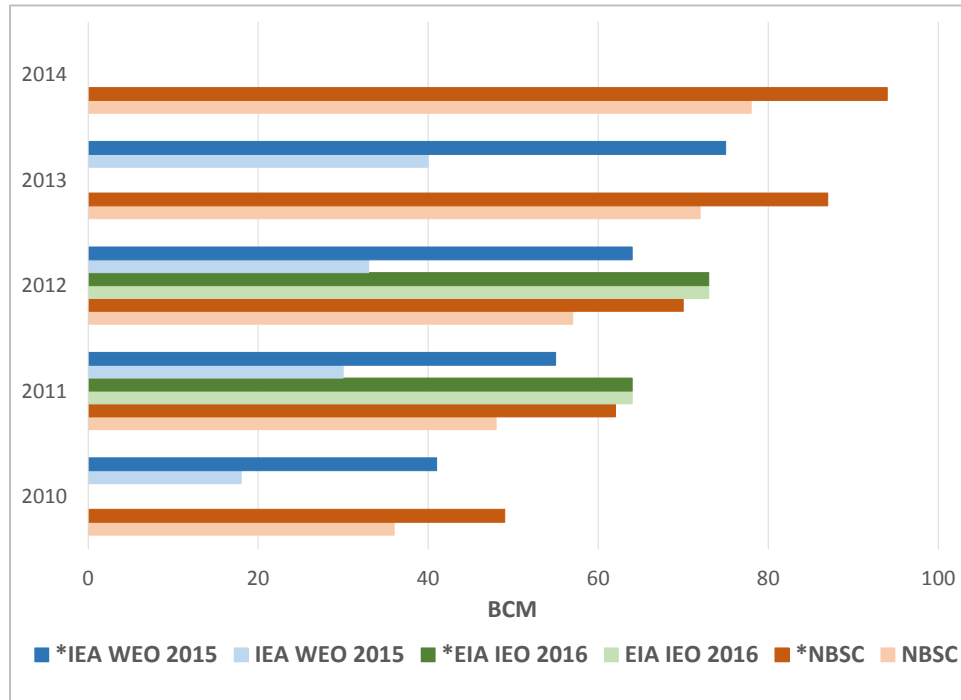
Sources: MOPNG, BP SR 16, IEA WEO 15 Gas Balance, EIA IEO 16.

The historical sector data reported by China and India's government agencies (the NBSC and MOPNG, respectively), the IEA and the EIA categorize sector gas consumption differently. The largest differences



are in reported gas consumption by the industrial sector.²⁵³ We re-categorized the reported information to make the industrial sectors more comparable among the data reporters. Total gas consumption by all sectors remains unchanged. The original and revised categories are summarized in Figure 48 below.

Figure 48. China Historical Industrial Gas Demand as Reported and Revised (BCM)



Note: *As revised by CEE. Sources: NBSC, EIA IEO 2016, IEA WEO 2015²⁵⁴, IEA Gas Balances data provided to CEE.

In addition, there are time differences among the reported historical sector gas demand data series. As of this writing, China's NBSC has sector gas demand for each calendar year 2005 to 2014. India's MOPNG has sector gas demand that includes LNG imports for each fiscal year (April 1-March 31) 2011-12 to 2014-15. MOPNG sector gas demand data prior to 2011-12 does not include LNG consumption. The most recent IEA World Energy Outlook (2015) has sector gas demand for 2010-2013 and the most recent EIA International Energy Outlook (2016) reports sector gas demand for only 2011 and 2012.

The NBSC and IEA do not include energy sector own gas use in the industrial sector gas consumption; the EIA does include energy sector own gas use as industrial demand. The NBSC puts 94% of energy sector own use in the mining category and the IEA reports it in the "other energy sector" total energy use. We added back energy sector own use to the industrial category for NBSC and IEA. The EIA includes agriculture and mining gas use as industrial gas demand; the IEA and NBSC report those sectors separately. The NBSC and EIA include chemical sub-sector non-energy gas use in the industrial sector but the IEA does not: we added back chemical sub-sector non-energy gas use to the IEA industrial sector and removed it from other. There are still relatively minor differences among the data reporters but there

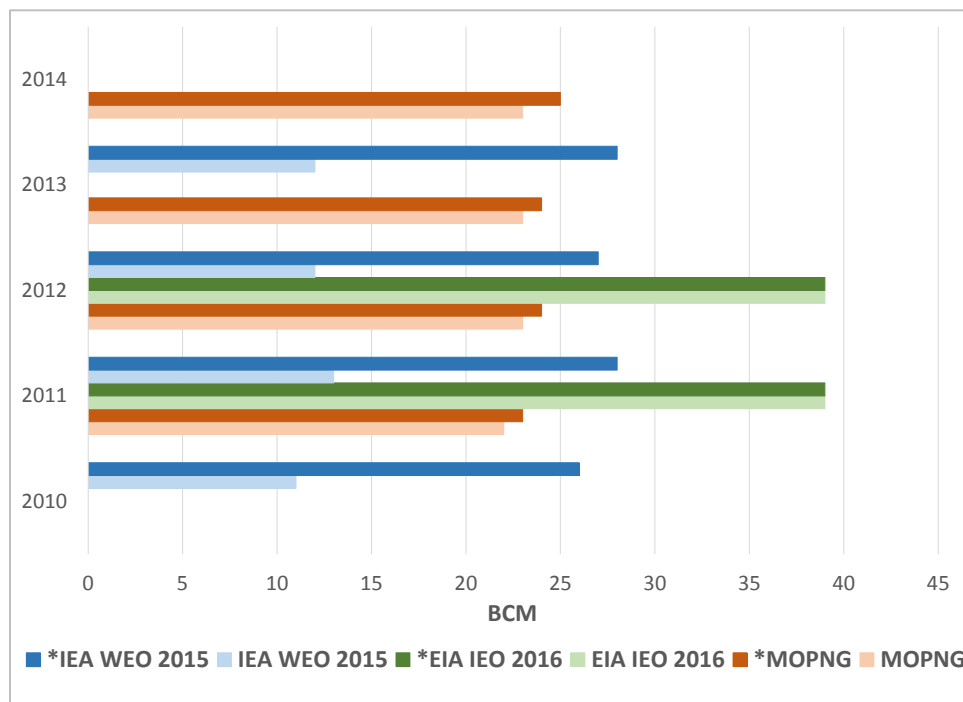
²⁵³ In China, the NBSC defines industrial gas use as the sum of manufacturing and power generation gas use. In this paper, power gas use is not part of industrial gas use and is analyzed separately.

²⁵⁴ Based on the Gas Balances data used in the WEO 2015 as provided by the IEA to CEE. All IEA historical gas demand data in this section is based on the Gas Balances data.

are no major gaps. China’s industrial sub-sectors will be discussed in more detail in the following section on forecast gas demand by sector section.

Energy sector own gas use in India is included in industrial gas demand by the EIA and IEA; we added it back to the MOPNG industrial demand. The MOPNG originally reported energy sector own use separately. The MOPNG and EIA included industrial non-energy gas use in the industrial gas demand sector but the IEA did not: we added it back to IEA industrial demand and removed it from other. The EIA includes non-oil and gas mining, agriculture and commercial volumes in industrial volumes which the IEA and MOPNG reports separately. However, these are small volumes and do not account for the entire difference between the EIA data and the revised data of the other two reporters. India’s industrial sub-sectors will be discussed in more detail in the following section on forecast gas demand by sector.

Figure 49. India Historical Industrial Gas Demand as Reported and Revised (BCM)



Note: *As revised by CEE. Sources: MOPNG, EIA IEO 2016, IEA WEO 2015, IEA Gas Balances data provided to CEE.

The industrial sector data for NBSC and IEA are revised. All other sectors and total gas use are as reported. In the residential/commercial sector, the IEA data may include commercial buildings. It is not clear why the EIA’s residential/commercial data appear high and their transport data appears low. The IEA other category is low as we reclassified some of their “other” to industrial.

Table 24. China Historical Gas Demand by Sector by Reporter as Revised (BCM)

Sector and Reporting Sources	2010	2011	2012	2013	2014
Industrial					
NBSC	49	62	70	87	94
EIA IEO 16		64	73		
IEA WEO 15 Gas Balance	41	55	64	75	



Sector and Reporting Sources	2010	2011	2012	2013	2014
Power					
NBSC	18	23	23	24	27
EIA IEO 16		22	22		
IEA	20	24	24	27	
Residential/Commercial					
NBSC	23	26	29	32	34
EIA IEO 16		36	39		
IEA WEO 15	27	31	35	38	
Transport					
NBSC	11	14	16	18	21
EIA IEO 16		3	3		
IEA WEO 15	8	11	12	14	
Other					
NBSC	6	6	8	10	10
EIA IEO 16		11	11		
IEA WEO 15 Gas Balance	2	1	2	2	0
Total Gas Use					
NBSC	107	131	146	171	186
EIA		137	148		
IEA	98	122	137	156	

Source: NBSC, EIA IEO 2016, IEA WEO 2015, IEA Gas Balances data provided to CEE; CEE revisions.

The industrial sector data for MOPNG and IEA are revised as discussed previously. All other sectors and total gas use are as reported.

Table 25. India Historical Gas Demand by Sector by Reporter as Revised (BCM)

Sector and Reporting Sources	2011	2012	2013	2014
Industrial				
MOPNG	23	24	24	25
EIA IEO 2016	39	39		
IEA WEO 2015	28	27	28	
Power				
MOPNG	23	16	11	11
EIA IEO 2016	22	17		
IEA WEO 2015	26	21	15	
Residential/Commercial				
MOPNG ²⁵⁵	6	6	6	5
EIA IEO 2016 ²⁵⁶	3	3		
IEA WEO 2015	4	4	4	
Transport				
MOPNG				

²⁵⁵ The MOPNG reports city gas distribution gas demand which includes the residential, commercial and transport sectors. Transport gas demand is not reported separately.

²⁵⁶ Residential gas consumption only. The EIA reports zero volumes for the commercial sector.



Sector and Reporting Sources	2011	2012	2013	2014
EIA IEO 2016	3	3		
IEA WEO 2015	2	2	2	
Agriculture				
MOPNG ²⁵⁷	0.2	0.2	0.2	0.2
EIA IEO 2016				
IEA WEO 2015	0.2	0.2	0.2	
Other				
MOPNG	9	8	8	6
EIA IEO 2016	0	0		
IEA WEO 2015	0	0	0	
Total				
MOPNG	61	54	49	47
EIA IEO 2016	67	62		
IEA WEO 2015	61	54	49	

Source: MOPNG, EIA IEO 2016, IEA WEO 2015, IEA Gas Balances data provided to CEE, CEE revisions.

We do not have sufficient information to revise IEA forecasted industrial demand. As a result, IEA forecast industrial volumes will appear low relative to historical industrial volumes and low relative to other forecasters. The IEA forecast “other” category will appear high relative to other forecasters.

Natural Gas Demand Forecasts

While our focus in this paper is on drivers for natural gas demand growth over the next 20 years, and signposts to monitor, we include discussion on public domain and proprietary outlooks for context.

We review two public forecasts of Chinese and Indian natural gas demand: the IEA World Energy Outlook 2015 (WEO) and the U.S. EIA International Energy Outlook 2016 (IEO). From the WEO, we capture the New Policies Scenario (NPS), which is presented as the “central” case. However, since this scenario assumes climate pledges for COP21 to be implemented along with other government policies, it has even greater uncertainty than what might typically burden forecasts. Accordingly, we also present the Current Policies Scenario (CPS). From the EIA forecast we used their Reference Case. In addition, we reviewed forecasts provided to CEE of Chinese and Indian natural gas demand from BMI Research, a Fitch Group company; McKinsey Energy Insights; and ICIS. For India we include two additional forecasts: (1) Vision 2030 prepared for the Indian government, and (2) a March 2016 forecast by ICRA, a Moody’s Investors Service company.

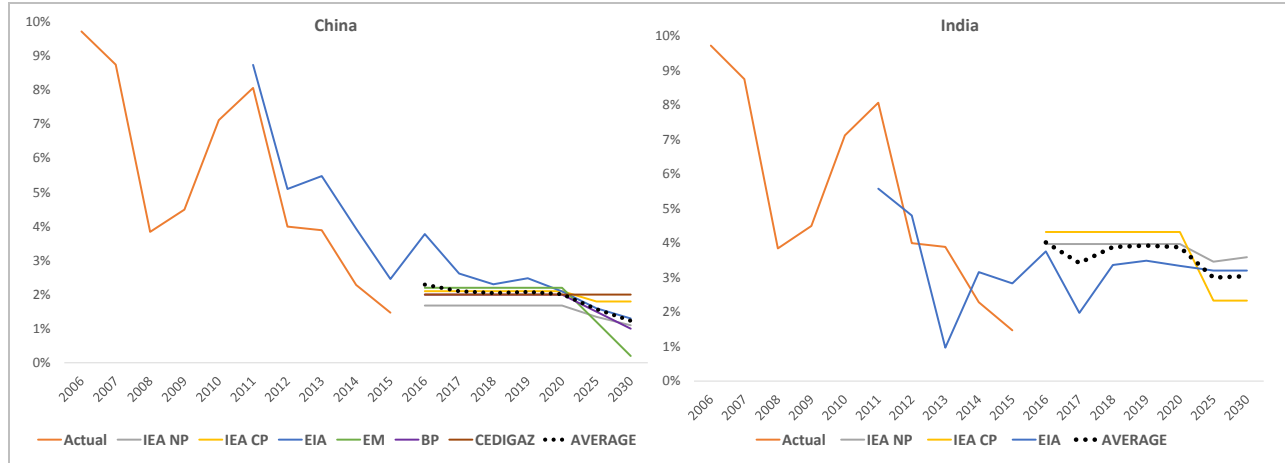
We supplement these projections, where possible, with insights gained from other public forecasts such as ExxonMobil’s 2016 Outlook for Energy, BP’s 2016 Energy Outlook, and other public analyses of future Chinese and Indian natural gas demand. Many of these sources also look at future gas demand by end-use sectors but do not publish the details of their analyses in a manner comparable to the IEA and EIA.

Before we delve into the details of the natural gas demand forecasts, it is useful to compare primary energy demand growth expectations in China and India. These are highlighted in the following Figure 50.

²⁵⁷ Tea plantation gas use.



Figure 50. Historical Primary Energy Demand Growth and Forecasts for China and India



Sources: as noted on charts and in text.

Table 26. Primary Energy Growth Rates for India, China

Year	India (BP SR 2016)	China (BP SR 2016)	China (NBSC as of August 5, 2016)
2006	5.2	9.7	9.6
2007	8.8	8.7	8.7
2008	5.7	3.8	3.2
2009	8.3	4.5	4.7
2010	5.0	7.1	7.4
2011	4.4	8.1	7.2
2012	6.1	4.0	3.9
2013	4.4	3.9	3.7
2014	6.4	2.3	2.2
2015	5.2	1.5	0.9

Source: NBSC, total consumption of energy and its composition, <http://data.stats.gov.cn/english/tablequery.htm?code=ACOH>.

Sources for figures and table: National Bureau of Statistics China and BP Statistical Review of World Energy 2016 for actuals, ExxonMobil 2016 Outlook for Energy (EM); Energy Information Administration International Energy Outlook 2016 (EIA); International Energy Agency World Energy Outlook 2015 New Policies scenario (IEA NP) and Current Policies scenario (IEA CP); BP 2016 Statistical Review/Energy Outlook (BP SR); and CEDIGAZ Medium and Long Term Energy Outlook 2015.

Most forecasters expect primary energy consumption growth to slow down in China (Figure 50) as the country emerges from a period of rapid and large industrialization and evolves into a more services-dominated economy. The average of all forecasts is 2.3% in 2016, declining to 2% by 2020 and falling to 1.6% by 2025. Primary energy demand growth forecasts for India cover a wider range than those for China. However, on average, India’s energy consumption is expected to flatten out and decline.

Given the vagaries of data to underpin projections, much less rapidly shifting paradigms on economic growth and performance, it is no surprise that forecasts can be subject to substantial revision. This is not to say that there is such a thing as an outlook that is not subject to change. The issue resides more in the confidence intervals around inputs and assumptions. The less reliable the inputs, the less reliable the outputs, with wider envelopes of potential error. As a simple illustration we built a longitudinal

evaluation of IEA World Energy Outlook views on natural gas demand in the two countries. By comparing different outlooks over time for one public reporting entity, we can better assess the extent of variability. We can also deduce something about the degree of uncertainty within the reporting entity. The charts in Figure 51 and Figure 52 provide these comparisons. These are not intended, in any way, to serve as a critique but rather to point to inherent complexities. Of the two countries, outlooks for China appear much more certain. However, in our analysis we point to a number of considerations, such as industrial over-capacity and the impact of that inefficiency on China’s fiscal balances. If addressed, the picture could be altered substantially. By comparison, and rightly, outlooks on India are much more variable. If anything, we suspect that confidence intervals around future Indian natural gas demand might be even more fragile than suggested by our depiction. A key implication in our work is that confidence intervals can only be improved with better information on the fundamental components of natural gas use. For that to happen, extensive improvements in data quality and reporting timeliness will be required.

Figure 51. IEA WEO Outlooks on China Natural Gas Demand

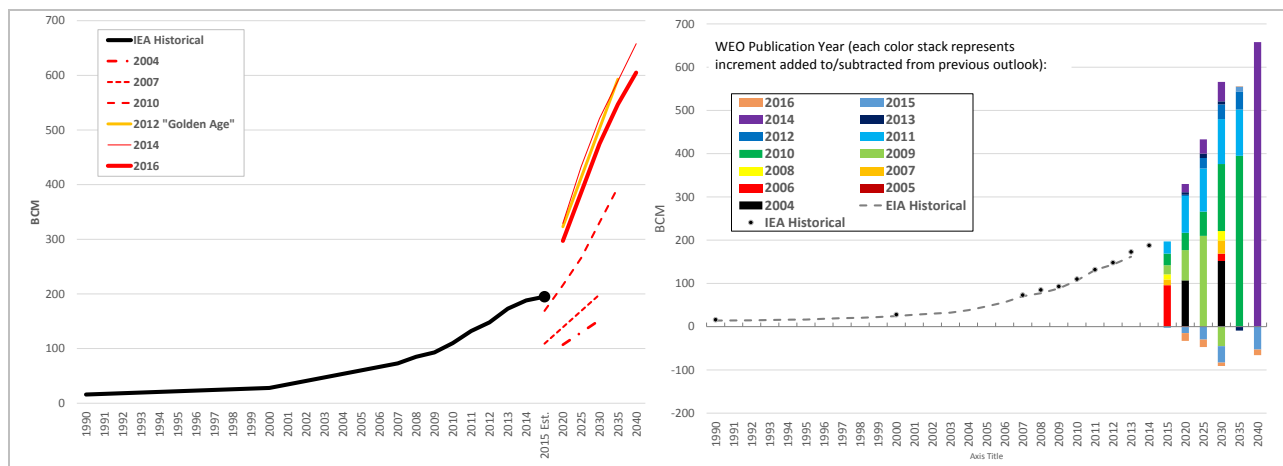
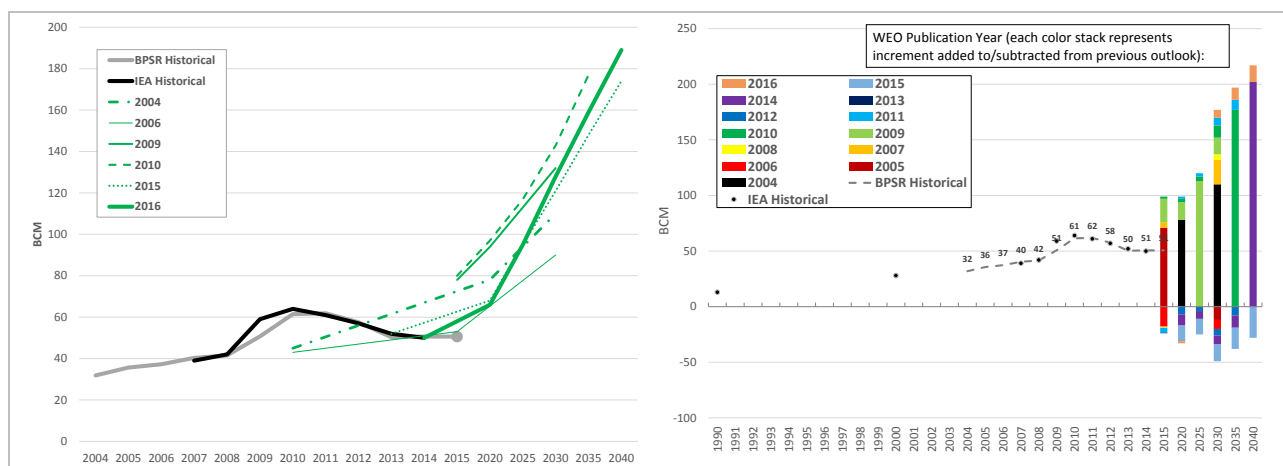


Figure 52. IEA WEO Outlooks on India Natural Gas Demand



Comparative forecasts of natural gas demand for China’s major end use sectors follow in Table 27. These provide a range of viewpoints regarding possible futures.



Table 27. China Forecast Comparisons BCM²⁵⁸

	2016	2017	2018	2019	2020	2025	2030
Industrial							
IEA NPS					75	102	124
IEA CPS					78		132
EIA Ref					126	168	212.8
McKinsey	103				122	140	158
ICIS	101	108	119	130	139		
Power							
IEA NPS					72	103	131
IEA CPS					71		122
EIA Ref					56	109	134
McKinsey	45				80	134	199
ICIS	36	41	47	55	62		
Res/Comm							
IEA NPS					69	84	101
IEA CPS					71		110
EIA Ref					73	92	118
McKinsey	54				72	92	109
ICIS	61	67	71	75	82		
Transport							
IEA NPS					19	23	28
IEA CPS					15	14	18
EIA Ref					11	22	45
McKinsey	22				31	44	63
ICIS							
Other							
IEA NPS					44	39	31
IEA CPS					44		25
EIA Ref					0	3	2
McKinsey	0				0	0	0
ICIS	0	0	0	0	0	0	0
Total							
IEA NPS					280	352	416
IEA CPS					279		407
EIA Ref					266	395	512
BMI	204	223	245	265	288	358	
McKinsey	224				305	410	529
ICIS	198	216	237	260	283		

Sources: IEA WEO 15, EIA IEO 16, Energy Insights McKinsey 2016; ICIS China gas demand 2016.

²⁵⁸ Forecast sources: (1) BMI Research, 2016, April, China Oil & Gas Report Q3 2016; (2) Energy Insights, 2016, June, Asia gas outlook to 2030, McKinsey Solutions; (3) ICIS, 2016, A snapshot of China's natural gas demand 2016-2020; (4) IEA WEO 2015, NPS and CPS scenarios; (5) EIA IEO 2016 Reference Case.



China consumed 99 BCM of natural gas in the first half of 2016 due to lower gas prices domestically and internationally. If that level is sustained in data for the second half of 2016, gas consumption is on track to reach 200 BCM for 2016 which is the consensus forecast level of BMI, McKinsey and ICIS. The 2020 forecasts are all in the same ballpark of a little less than 300 BCM with McKinsey on the high side. Forecasts begin to diverge in 2025 continuing in 2030 with IEA low (350-416 BCM) and McKinsey (410-529 BCM) and EIA (395-512 BCM) high. EIA is very bullish on industrial and residential/commercial gas consumption. [With respect to industrial use, the reader should recall that EIA has the broadest definition of industrial demand including energy sector own use and non-energy industrial use which is in “other” for IEA. As a result, the “other” sector gas consumption in the IEA forecasts range from 25 to 44 BCM compared to zero in the other forecasts.] EIA has a 3% p.a. growth rate for Chinese steel production despite the severe overcapacity situation. Bulk chemicals production grows at 5% p.a. in the EIA forecast as reducing dependence on commodity chemical imports remains a government goal. Although EIA expects the coal share of China’s chemical feedstock fuel use to increase from 20% in 2012 to 32% in 2040 due to its use in ethylene production, EIA staff expect gas use as a feedstock for methanol and ammonia production to increase over the forecast period. Currently coal is used as a feedstock for 70% of ammonia production and 80% of methanol production. The EIA expects the following factors to restrain growth in coal for feedstock use due to: high capital costs for coal-to-olefin (CTO) plants; fewer valuable coproducts in the CTO process; high CO₂ emissions from CTO—more than twice that of a naphtha steam cracker; CTO is water intensive and CTO plants are or will be in water-stressed areas in Inner Mongolia and western China. The EIA expects China to be the world’s largest residential energy consumer by 2040 driven by urbanization. Gas use in the residential sector grows faster than electricity use although electricity will account for 42% of residential sector energy use by 2040.

McKinsey expects industrial gas demand to grow at a CAGR of 3.1% from 2016 to 2030. Gas use as a feedstock in chemical production is expected to “stabilize” with growth in industrial gas use coming from fuel switching from coal and heavy oil under environmental pressure from local governments and “economics favoring LPG switching to gas in the long run.” McKinsey is very bullish on gas use in the power sector (CAGR 2016-30 of 11.13%) due to the introduction of a carbon cap and trade system although they acknowledge that “diversification to renewables in the power mix has higher priority for the government.” McKinsey expects strong growth (CAGR of 7.92% 2016-2030) in gas use in the transport sector due to strong government support for NGVs, mainly for public transportation. Vehicle oil to gas switching in the short term, however, is restrained by low oil and oil product prices. Residential/commercial gas demand grows at a 5.17% CAGR as a result of increasing urbanization and rising household incomes.

ICIS expects slower gas demand growth in the short term due to the NDRC’s current gas pricing mechanism and sluggish Chinese economy but increasing at an 8.9% CAGR from 2016 to 2020. Power sector gas use will increase from 18% of total gas use in 2016 to 22% in 2020. Chemical feedstock gas use will decline from 13% of total gas use in 2016 to 9% in 2020 due to a government preference for coal. Industrial sector (not including chemical feedstock) gas use will increase slightly from 38% of total gas use in 2016 to 40% in 2020. City gas distribution (residential, commercial and transport) gas use will decline from 32% of total gas use in 2016 to 29% in 2020.

BMI Research expects the Chinese government to implement its policy to increase the natural gas share of the primary energy mix from 6% to 10% by 2020. Total gas demand will grow at a 7% CAGR 7% from 2016 to 2025. Current lower prices increase natural gas competitiveness with alternatives which, together with government pressure, encourages fuel switching to gas. Like McKinsey, BMI expects a carbon cap and trade system to boost natural gas demand post-2017. Downside risks to the BMI forecast include cost competitive coal especially in the power sector. Non-hydro renewables and nuclear have higher shares of total generation in 2020 and 2025 (Table 28).

Table 28. BMI Research China Generation Fuel Sources²⁵⁹

	2014	2020	2025
Coal Generation % Total Generation	72%	62%	54%
Natural Gas Generation % Total Generation	1.5%	3%	5.4%
Nuclear Generation % Total Generation	2.3%	4.6%	7.6%
Non-Hydro Renewables Generation % Total Generation	4.7%	8.3%	9.6%

Source: BMI Research, 2016, March, China Power Report Q2 2016.

The IEA NPS²⁶⁰ WEO15 asserts that “the case for gas use in China is a strong one.” The most important driver is “the need to improve urban air quality.” Reduction in air pollution and the need for more flexible peaking capacity drive growth in power sector gas demand with gas generation increasing from 2% of total generation in 2013 to 8% in 2040. Power gas use could be limited by cheap coal, relatively expensive natural gas import prices, and alternate ways of achieving power sector flexibility such as electricity storage and demand side management and government policy support for renewables. IEA expects total renewables generation as a percent of total generation to increase from 4% in 2013 to 17% by 2040 due to government policy support. Industrial demand will increase due to continued economic expansion and coal-to-gas and oil-to-gas substitution although steel production is expected to decline 30% by 2020. Demand for natural gas for transport use grows due to oil-to-gas substitution. The need for environmentally friendly residential heating in large parts of China and the expansion of CGD infrastructure will grow residential gas demand. Gas use as a percentage of total primary energy use increases from 5% in 2013 to 11% by 2040.

On a total gas use basis, there is not much difference between the IEA WEO NPS and CPS demand scenarios (Table 29). Industrial and residential/commercial gas use are slightly higher in CPS as a result of limited pollution and climate change policies. Power sector gas use is slightly lower in CPS and transport gas use is significantly lower in CPS without policies to support NGVs.

²⁵⁹ BMI Research, 2016, March, China Power Report Q2 2016.

²⁶⁰ The IEA New Policies Scenario (NPS) incorporates current policies and measures that affect energy markets as well as announced but not implemented policies such as the Intended Nationally Determined Contributions (INDCs) submitted by national governments in October 2015 to combat climate change. It also includes announced but yet to be implemented programs supporting renewables and improved energy efficiency, carbon pricing, alternative transport fuels, energy subsidy reforms and the introduction, expansion or phase-out of nuclear power. Oil, natural gas and OECD steam coal imports prices through 2020 are almost the same in the NPS and CPS scenarios but CPS prices are about 15% than NPS prices by 2030 and 2040. See Table 29.



Table 29. IEA WEO15 Fossil Fuel Import Prices by Scenario.

	New Policies Scenario				Current Policies Scenario		
	2014	2020	2030	2040	2020	2030	2040
Real terms (2014 prices)							
IEA crude oil imports (\$/barrel)	97	80	113	128	83	130	150
Natural gas (\$/MBtu)							
United States	4.4	4.7	6.2	7.5	4.7	6.3	7.8
Europe imports	9.3	7.8	11.2	12.4	8.1	12.5	13.8
Japan imports	16.2	11.0	13.0	14.1	11.4	14.9	16.0
OECD steam coal imports (\$/tonne)	78	94	102	108	99	115	123

Source: IEA CPS WEO15²⁶¹

All of the India total gas consumption forecasts, with the exception of the GOI Vision 2030, are in the same ballpark (70 BCM in 2020; 90 BCM in 2025 and 115 BCM in 2030) with ICRA on the high side at 92-104 BCM and BMI Research on the low side (65-85 BCM). ICRA’s power sector gas use forecast for 2020 is almost double the other forecasts excluding Vision 2030. Achievement of the early years ICRA forecasts depends on continued low domestic and international gas prices, significant expansion of the pipeline system which has been stalled in recent years, and resolution of long-standing structural issues in the power industry. Although BMI expects 6.8% p.a. GDP growth 2016-2019, both the fertilizer and power sectors, the two largest natural gas consumers, require continued low prices to grow as well as significant pipeline additions and government financial support for the two sectors. BMI is less optimistic than ICRA on these issues.

Table 30. India Forecast Comparisons BCM

	2016	2017	2018	2019	2020	2025	2030
<i>Industrial</i>							
IEA NPS					20	26	31
IEA CPS					20		30
EIA Ref					48	56	67
McKinsey	31				37	45	53

²⁶¹ The IEA’s Current Policies Scenario (CPS) includes only those policies with formally adopted implementing measures as of mid-2015 and assumes unchanged persistence of these policies over the forecast period. In the CPS policies to reduce the use of fossil fuels are limited so rising demand and supply costs combine to purchase fuel prices up by about 15% by 2030.



	2016	2017	2018	2019	2020	2025	2030
ICRA	39	40	42	42	45	52	
GOI Vision 2030					63	84	111
<i>Power</i>							
IEA NPS					20	37	49
IEA CPS					22		54
EIA Ref					11	14	22
McKinsey	17				21	26	32
ICRA	39	39	39	39	39	39	
GOI Vision 2030					58	80	129
<i>Res/Comm</i>							
IEA NPS					6	6	7
IEA CPS					4		7
EIA Ref					3	6	8
McKinsey	8				11	17	23
ICRA	6	6	7	7	8	13	
GOI Vision 2030					8	15	31
<i>Transport</i>							
IEA NPS					1	2	4
IEA CPS					1		4
EIA Ref					6	8	17
McKinsey	2				3	3	5
ICRA							
GOI Vision 2030							
<i>Sub-Total</i>							
IEA NPS					47	70	90
IEA CPS					47	0	95
EIA Ref					67	84	112
McKinsey	58	0	0	0	72	91	113
ICRA	84	86	88	88	92	104	0
GOI Vision 2030	0	0	0	0	129	179	271
<i>Other</i>							



	2016	2017	2018	2019	2020	2025	2030
IEA NPS					17	20	24
IEA CPS					20	0	23
EIA Ref					3	3	0
McKinsey					0	1	0
ICRA					0	0	0
GOI Vision 2030					9	0	1
TOTAL							
IEA NPS					64	90	114
IEA CPS					67		118
EIA Ref					70	87	112
BMI	55	58	62	65	69	85	
McKinsey	58				72	92	113
ICRA	84	85	88	88	92	104	
GOI Vision 2030					138	179	272

Sources: BMI Research, 2016, March, *India Oil & Gas Report Q2 2016*; Energy Insights, 2016, June, *Asia Gas Outlook to 2030*, McKinsey Solutions; ICRA Gas Utilities Report, 2016, March, [Indian gas utilities; domestic gas output to rise in long term following reforms; recent PNGRB notification a marginal plus for transmission sector](#); Government of India, 2013, May, *Industry Group Report for the Petroleum & Natural Gas Regulatory Board of India, Vision 2030: Natural gas infrastructure in India*, <http://www.pngrb.gov.in/Hindi-Website/pdf/vision-NGPV-2030-06092013.pdf>. IEA WEO 2015. EIA IEO 2016. Note that in the Res/Comm sector outlook the GOI Vision 30 forecast of 31 BCM based on city gas distribution (CGD) includes transport.

The GOI Vision 2030 is the oldest forecast: it was prepared in 2012 and released in 2013 so it is probably outdated. In addition, Vision 2030 does not consider factors which could constrain gas demand growth such as price and access to infrastructure.

EIA also has the most bullish industrial and transport gas demand forecasts. EIA expects increases in Indian basic chemical production and in nonmetallic mineral production due in part to rapid growth in its domestic construction industry. India's share of world steel production increases in the EIA's forecast while China's remains flat.

McKinsey sees total Indian gas demand growing at a 4.9% CAGR 2016-2030. Strong GDP growth (6.3% pa) will fuel an industrial gas demand CAGR of 4%, made possible by increased supply, primarily LNG imports (domestic supply will increase from 32 BCM in 2016 to 40 Bcm in 2025 and LNG imports from 25 Bcm to 77 Bcm over same period). Power gas demand growth of CAGR 4.7% pa requires changes to commercial frameworks: gas will start replacing coal as soon as carbon taxes are put in place and regulations preventing gas to be sold at high prices to inelastic customers are abolished. The residential/commercial sector gas demand will grow at an 8% CAGR 8.0% due to the government prioritizing residential/commercial gas consumption over the other Tier 1 demand sectors. McKinsey

assumes that the required CGD systems are constructed. Near term transport gas demand growth is constrained by severe competition from alternative fuels, primarily currently cheap oil products.

BMI expects fertilizer gas demand to grow if current low gas prices persist. (India has some of the lowest gas prices in Asia-Pacific compared to China, Thailand(\$11/MMBtu), Indonesia (\$10.5/MMBtu) and the Phillipines (\$8.20/MMBtu). Power sector gas demand will grow if delivered gas prices are below \$8-\$9/MMBtu; at higher prices, gas is economic for peaking only. Financial backing from the government will be necessary given the limited ability of power producers to pass on cost increases to the consumer. BMI's gas demand growth forecast requires significant gas pipeline additions. Without the infrastructure, forecast growth is not achieved. If LNG supply prices are tied to oil prices in the future and oil prices exceed \$75/bbl, it will be too expensive for Indian markets. Finally, commercial frameworks in the gas and power industries need reform if market is to grow.

In its NPS, IEA does not expect a dramatic shift in the primary energy mix. Coal's share of primary energy use will increase from 44% to 49% in 2040. The increase in coal use will be split between power generation (to feed an additional 265 GW of coal plants) and industry for iron, steel and cement. Shares of oil and natural gas in the primary energy mix will "edge slightly higher." Biomass use remains stable in absolute terms but drops from 25% of the primary energy mix in 2013 to 11% in 2040. "Natural gas plays a relatively minor role in the Indian energy mix in the NPS." (IEA WEO 15, page 469). Gas will retain an important role as fertilizer feedstock. The "relatively high price for gas does not allow it to displace other forms of energy more rapidly."

In the power sector, coal will continue to be the dominant generation fuel. Gas use will grow from 5% of total generation energy use in 2013 to 9% in 2030 but its growth will be outstripped by the growth in use of non-hydro renewables. By 2030 non-hydro renewables will account for 15% of total generation compared to 5% in 2013. Wind and solar will account for 80% of the renewables generation use by 2030.

Table 31. IEA NPS India Power Sector Outlooks

India Generation Fuel ²⁶² Sources	2013	2020	2030
Coal Generation % Total Generation	73%	70%	60%
Gas Generation % Total Generation	5%	5%	9%
Nuclear Generation % Total Generation	3%	4%	6%
Non-Hydro Renewables Generation % Total Generation	5%	10%	15%

Source: IEA WEO 2015.

The IEA expects that the commercial services sector energy use will be based primarily on electricity. Gas use for cooking in urban areas will grow from around 1% of total energy use for cooking in 2013 to around 15% in 2040. LPG will remain the dominant cooking fuel in urban areas: close to 70% of total cooking energy use in 2013 and growing to 80% in 2040. In rural areas, there is almost zero use of gas for cooking and that is not expected to change: biomass will predominate in rural areas and LPG cooking use will grow from around 15% in 2013 to about 30% in 2040.

Coal use in the industrial sector will increase from 50% of total industrial energy use in 2013 to 56% in 2040. Gas use by industry will grow in absolute terms but its share of total industrial energy use will decline held back by "subdued growth in domestic production, relatively high import prices and limited

²⁶² BMI Research, 2016, March, India Power Report Q2 2016.



distribution infrastructure” (IEA WEO15 page 478). Petrochemicals production relies heavily on domestic naphtha from the domestic refining industry. Aluminum production will increase four-fold by 2040 but it is electricity intensive.

Transport fuels will be dominated by gasoline and diesel over the forecast period, at about a 40/60 ratio, respectively. Today India has the sixth largest fleet of NGVs in the world, primarily taxis and buses with refueling networks in “several” cities. Gas use in road transport expands moderately over the forecast period but remains small in absolute terms.

Gas power generation capacity will grow from 8% of total generation capacity in 2014 to 10% in 2030. Power demand for gas is highly price sensitive. IEA does not expect gas-fired power plants to produce baseload power over the forecast period due to the relatively high cost of the fuel. Rather gas-fired power provides daily load following and peaking flexibility. Gas use for power increases from around 5% of total power energy use in 2013 to 10% in 2040. The share of all renewables in power generation increases from 17% in 2013 to 26% in 2040 with wind and solar PV together accounting for 65% of renewable power growth.

IEA WEO15 CPS: Like China, there is not much difference between the NPS and CPS on a total gas use basis. Industrial and transport gas demand are about the same. Power gas use is higher in CPS due to less support for renewables. Increases in residential/commercial gas use are slightly slower in CPS.