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Global Gas Demand – Understanding the Next 20 Years

China Case Study

Foss, Michelle Michot, Ph.D., Chief Energy Economist, Bureau of Economic Geology's Center for Energy Economics (BEG/CEE), The University of Texas at Austin, USA

Wainberg, Miranda, Senior Energy Advisor, BEG/CEE, UT Austin, USA

Gülen, Gürcan, Ph.D., Senior Energy Economist, BEG/CEE, UT Austin, USA

Table of Contents

Background

Global energy demand over the next two decades is expected to rise steadily as populations, incomes and economies continue to grow. Emerging economies and resource holders are expected to be at the forefront of this demand growth as they catch up with more mature economies in providing modern living standards to their populations. Most published energy market outlooks assign a significant role for natural gas in this energy demand growth, noting widespread supply availability; developing infrastructure in the form of pipelines and LNG facilities; ability to serve almost all end-use sectors; lower carbon-intensity and lower source of local air emissions than other fossil fuels; and complementarity to renewable energy in power generation to offset intermittency.

Aim

Notwithstanding this consensus, there are significant risks and uncertainties around the pathway of global gas demand. A University of Texas at Austin-led team is undertaking a focused study "deep dive" to explore the demand side of the natural gas equation in order to highlight the nature and extent of uncertainty in the major gas markets. Key questions posed in the study include "demand wedges" such as fuel competition in power generation; industrial sectors and trends; pricing policies; and exogenous policy and regulatory actions that cut across sectors and geographies.

The goals of the study are to understand and communicate with greater confidence the risks and uncertainties inherent in long-term natural gas market outlooks. Our intention is to assess what the level of demand *could be* for key countries and regions considering subsidy effects and given infrastructure constraints and needs.

Methods

For each major country or region studied, we identify the driving forces that are assumed, explicitly or implicitly, to underpin natural gas demand; we describe these driving forces, whether they be bottom up sectoral trends, economics, demographics, market structures, pricing policies or others; and highlight how and to what extent changes in their behaviour can lead to different outcomes and a different pathway for natural gas demand. We identify

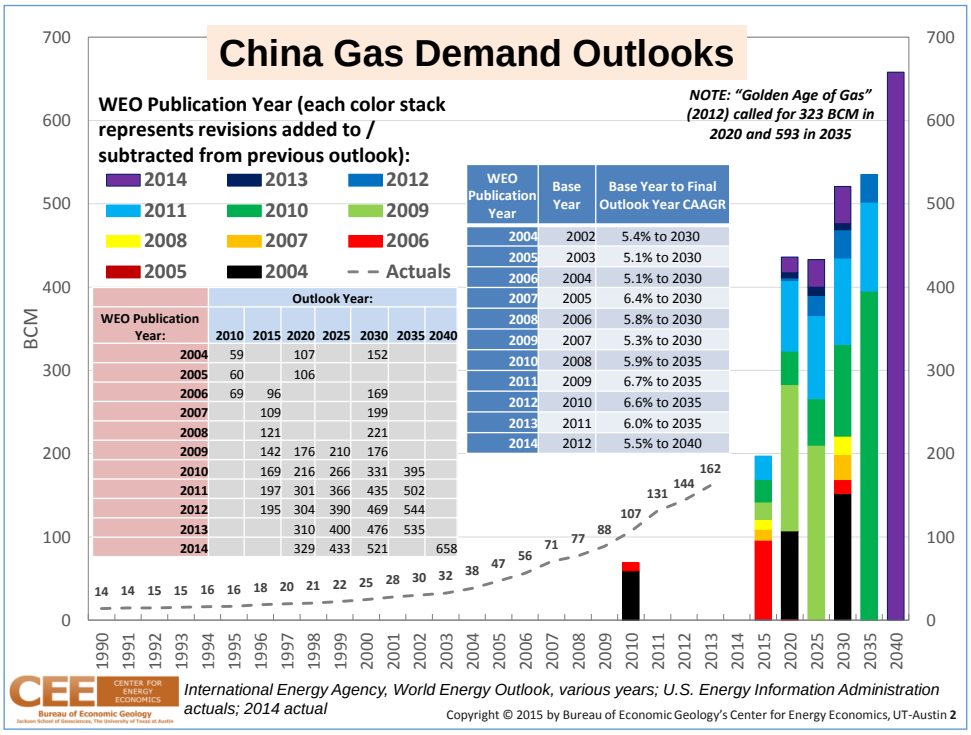
potential signposts and branching points to allow study users to anticipate and understand inflections from business-as-usual trends and points of contrast with consensus outlooks.

Results

Given its importance to natural gas trade flows and larger energy and economic outlooks, China was selected as the first test case. This paper presents work in progress from a ground up examination of China's natural gas value chain.

Expectations of growing natural gas demand for China are well established as shown in Figure 1 below using continuous releases of the International Energy Agency's annual World Energy Outlook. By some measures, China is now as large, if not larger than, the United States in total power generation output. Yet China ranks well below the U.S. in use of natural gas for power generation. Given energy needs for a country that also is nearly as large as the U.S. in economic output, it is not unreasonable to suggest that gas will constitute a significant portion of the power generation fuel mix as well as overall energy consumption. The IEA has Chinese natural gas use more than quadrupling over nearly 30 years, 2012-2040. By comparison, U.S. gas use did not quite double over nearly 50 years, 1965-2014, in a trajectory marked by considerable bumpiness. China and the U.S. are quite different countries, yet the U.S. experience illustrates how uncertain a gas consumption growth path can be. U.S. natural gas supply and deliverability was influenced by deeply changing views and cycles, constraining or accelerating demand. Concerted efforts since the 1980s to build a more price sensitive, competitive market framework along with other exogenous policy and economic factors (including environmental rules that encouraged gas use for power generation and strong recessions) resulted in highly variable annual growth rates. China also faces questions about gas supply and sourcing; is in the process of instilling a more price sensitive framework; and is subject to strong exogenous policy and economic forces. It is not unlikely that Chinese gas demand will be at least as variable.

Figure 1. China Gas Demand Outlooks

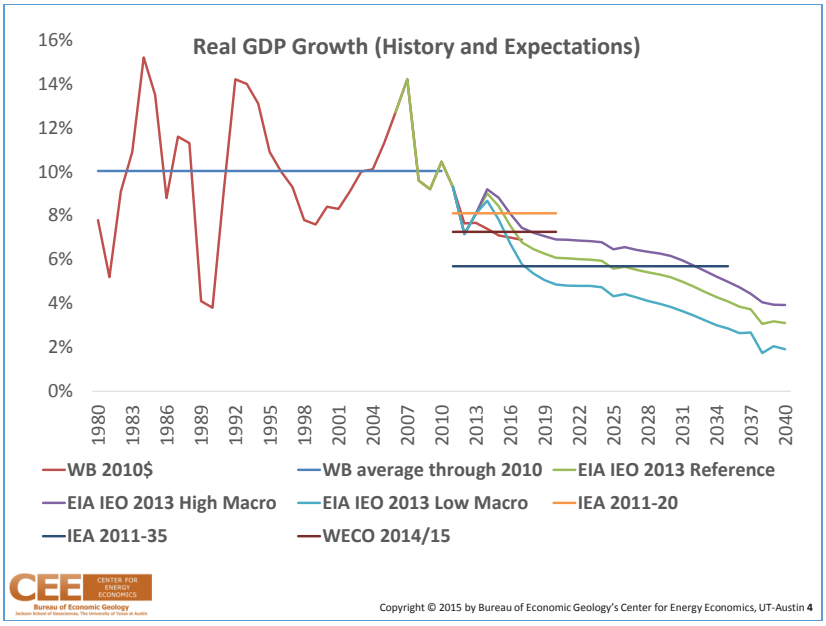


Source: International Energy Agency (IEA) World Energy Outlook (WEO), various years.

Economic and Energy Intensity Drivers

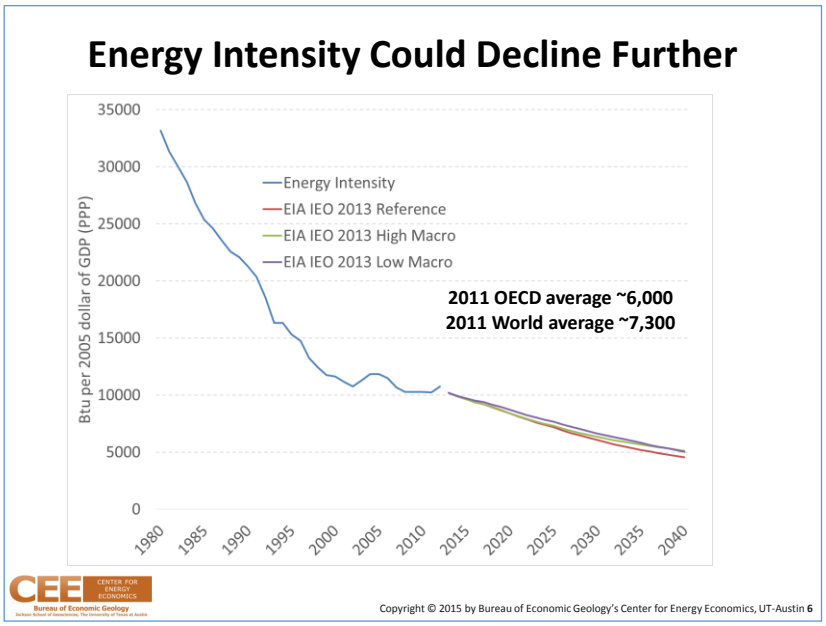
A significant source of risk and uncertainty stems from China's economic performance. Projected annual growth rates are lower than historical output, 7 percent for 2015 through 2020 (and lower after 2020) as opposed to 10 percent per year on average between 1980 and 2010 (see Figure 2). Lower economic growth rates going forward are consistent with stylized economic growth patterns and slowing population growth. More efficient use of energy in modernized facilities means lower energy intensity (energy use per unit of gross domestic product or GDP), though the rate at which modernized facilities are added should theoretically decrease as economic growth rates decrease. This is consistent with the observation that energy intensity declined significantly after 1980 but has been stable in recent years and remains higher than the world and Organization for Economic Cooperation and Development (OECD) averages. Electricity intensity continues to decline into the future using U.S. Energy Information Administration (EIA) forecasts as a proxy (Figure 3). The upshot is that Chinese energy consumption growth should slow faster than GDP. Intensity of electricity use exhibits similar tendencies, being very closely linked to GDP. Electric power intensity dropped sharply after 1990 and also remains flat through the EIA forecast horizon (Figure 4).

Figure 2. Chinese Real Gross Domestic Product (GDP) Growth and Forecast



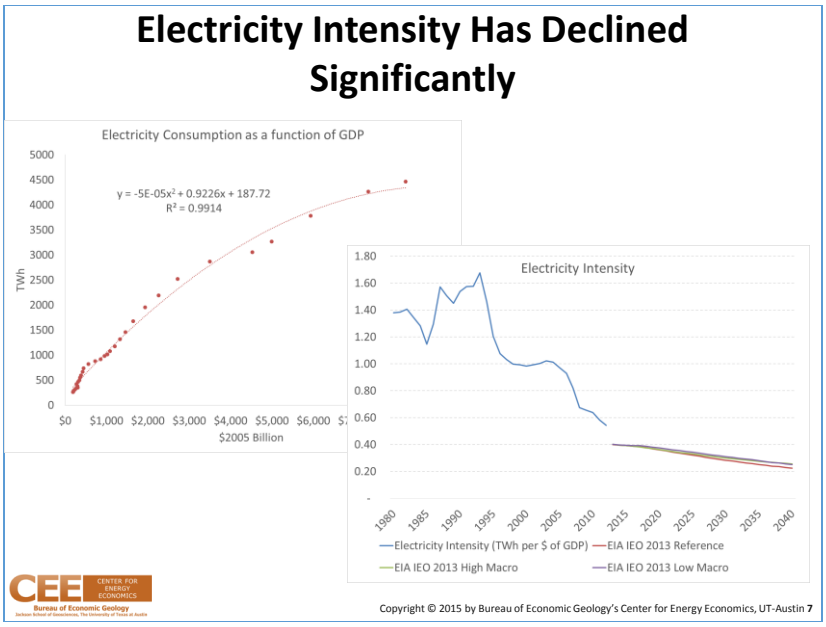
Source: IEA WEO 2014; U.S. Energy Information Administration (EIA) International Energy Outlook (IEO) 2013; World Bank (WB); World Energy China Outlook (WECO) 2014-15.

Figure 3. Chinese Energy Intensity Trend and Forecasts



Sources: EIA IEO 2013

Figure 4. Chinese Electricity Intensity Trend and Forecasts



Sources: EIA IEO 2013, BEG/CEE modelling.

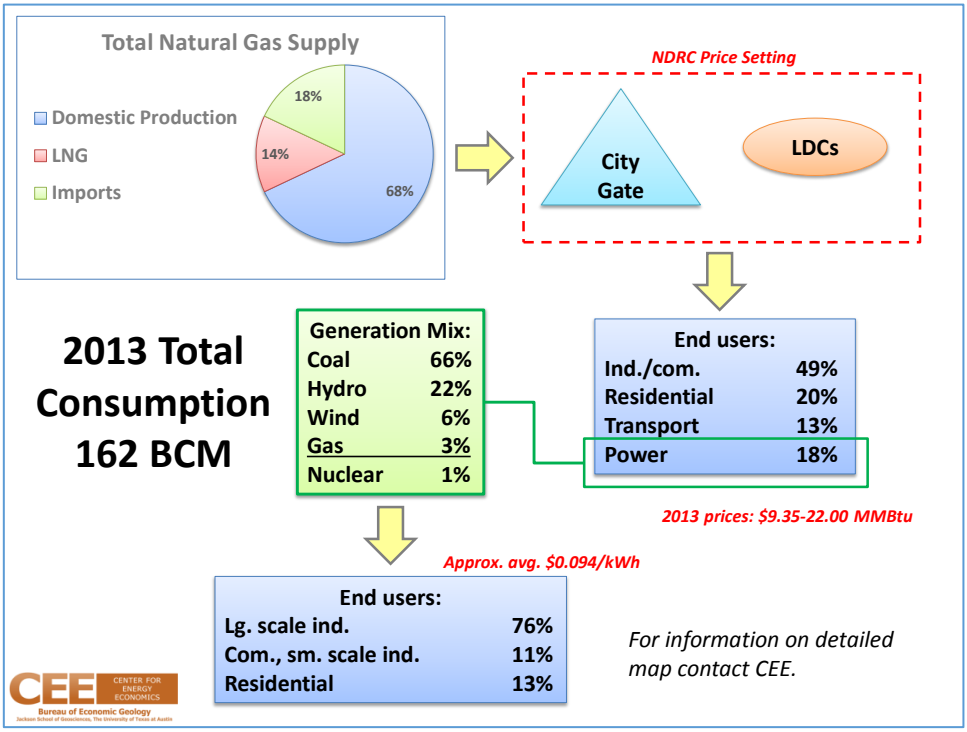
Mapping China's Natural Gas System

The first step in our analysis is to "map" China's natural gas value chain to ascertain complex linkages across supply and demand, varied user groups, price signals and policies and to identify key uncertainties. A simple version of our mapping is shown in Figure 5. Some of the complexities include the interaction between National Development Reform Commission (NDRC) pricing policies for city gate and local distribution companies (LDCs), the role of industrial customers as the major user group for both direct natural gas purchases and electric power (affecting gas use indirectly via power generation), and pricing policies for industrial customers relative to other sectors. The city gate price is regulated by the NDRC and can be adjusted by provincial governments. Distribution tariffs are regulated by local governments. Industrial gas prices, on average, are 30 percent higher than residential prices and 9 percent lower than transport prices.[1] The average gas tariff for industries in

[1] The industry classification includes power generators.

2013 ranged from $12.50 to $14.30 per million Btu (British thermal units, MMBtu). The industrial gas price is equal to the city gate gas price ($9.35/MMBtu in 2013) plus a distribution tariff ($3.15-$4.95/MMBtu in 2013). However, central and provincial governments also have historically subsidized gas prices to certain industries, resulting in a complicated landscape with respect to price signals.

Figure 5. Abbreviated Map of China's Gas Value Chain



Source: Developed by BEG/CEE based on various sources.

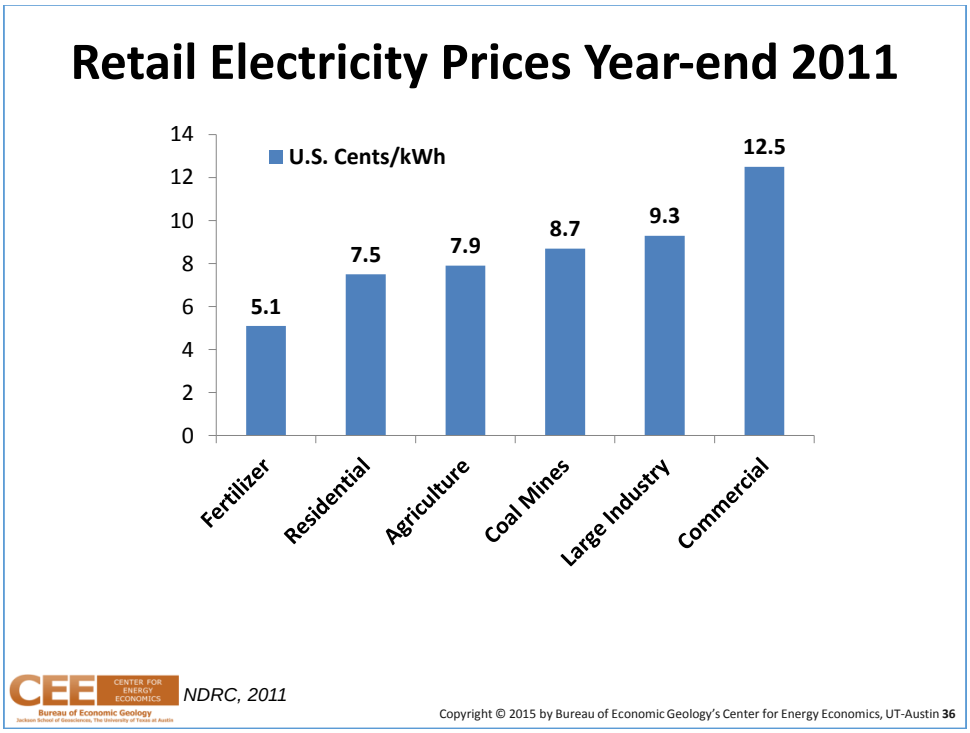
Effective 1 April 2015, the NDRC raised the city gate price of legacy gas (about 90 percent of total volumes) and lowered the price of incremental gas (about 10 percent of volumes). Incremental volumes are linked to fuel oil and LPG prices. This action resulted in one city gate price that is about 5 percent lower than previous prices after provincial adjustments. The new natural gas price ranges from a high of $12.69/MMBtu in Shanghai to a low of $8.00/MMBtu in Xinjiang. Going forward the NDRC will adjust the gas price based on a complicated formula of 85 percent of 60 percent of the fuel oil price and 40 percent of the LPG price. The current city gate price is perceived to be a ceiling particularly in coastal regions. Another price reduction is expected this year.

When it comes to electricity prices, the base rate is equal to the on grid tariff (OGT) plus the transmission and distribution (TD) rate, both set by the NDRC. The OGT is the rate paid by the state grid companies to power generators and is derived using the average cost of

comparable units, including fuel costs, plus tax and reasonable return. There is limited ability to pass through coal and natural gas fuel cost increases in the OGT.

The average OGT in 2010 was 6.2 cents/kWh and the TD was 2.6 cents/kWh for a total of 8.8 cents/kWh. OGT increases due to higher gas prices are capped at 5 cents/kWh above OGT coal prices. If the coal price fluctuates by more than 5 percent annually the OGT is adjusted with generators absorbing 10 percent of the fluctuation. The provinces can adjust the NDRC base rate (OGT plus TD) based on socioeconomic factors. While industrial and commercial customers cross-subsidize other consumers, including residential users, evidence indicates that many industrials are not paying the full regulated rate for electricity. In particular, fertilizer plants – important to some provincial economies – are favored. The unrecovered costs are absorbed by the state grid companies and, to a lesser extent, the power generators. This inhibits power system investment.

Figure 6. Retail Electricity Prices in China in 2011



Source: National Development Reform Commission (NDRC, now State Planning and Development Commission, SPDC)

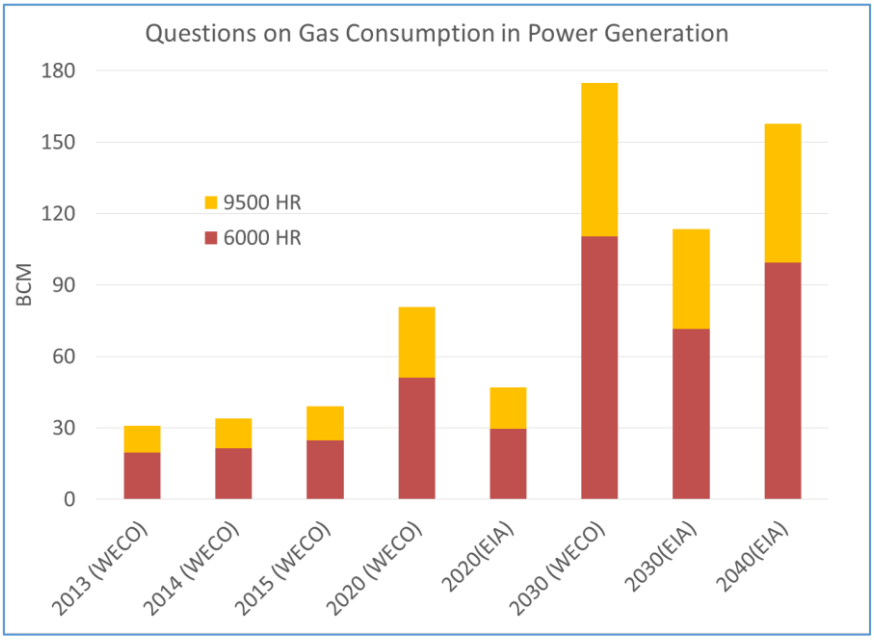
In January 2014 the NDRC implemented a three tier pricing system for aluminum smelters. Tier 1 is a base consumption level and has the lowest price. Tiers 2 and 3 are consumption levels above the base and have higher prices with Tier 3 having the highest price.

The government intends to extend the three tier system to other "energy guzzling" industries but the timing is uncertain. If enforced, the tiered pricing system will drive less efficient companies to alter their production processes or shut down. In June 2013 the National Energy Agency (NEA) implemented a program in 10 provinces allowing large industrials to freely negotiate purchase prices and volumes from power generators. The timing of the extension of this program to other provinces is uncertain.

Power System Features and Role of Gas

With respect to how much gas is used specifically for power generation, understanding China's generation fleet and how the fleet is utilized (capacity factors) is critical. Thus far, we have not been able to nail down an exact estimate of how many terawatt hours (TWH) are generated from gas. Estimates range from 115 TWH (see Xu, 2015) to about 200 TWH (see Chen, 2014). Thirty BCM of gas is reportedly consumed for power generation but it is not clear whether this is from very efficient plants generating 200 TWH or inefficient plants generating 115 TWH (9,500 heat rate case in Figure 7).

Figure 7. Gas Consumption in Chinese Power Generation

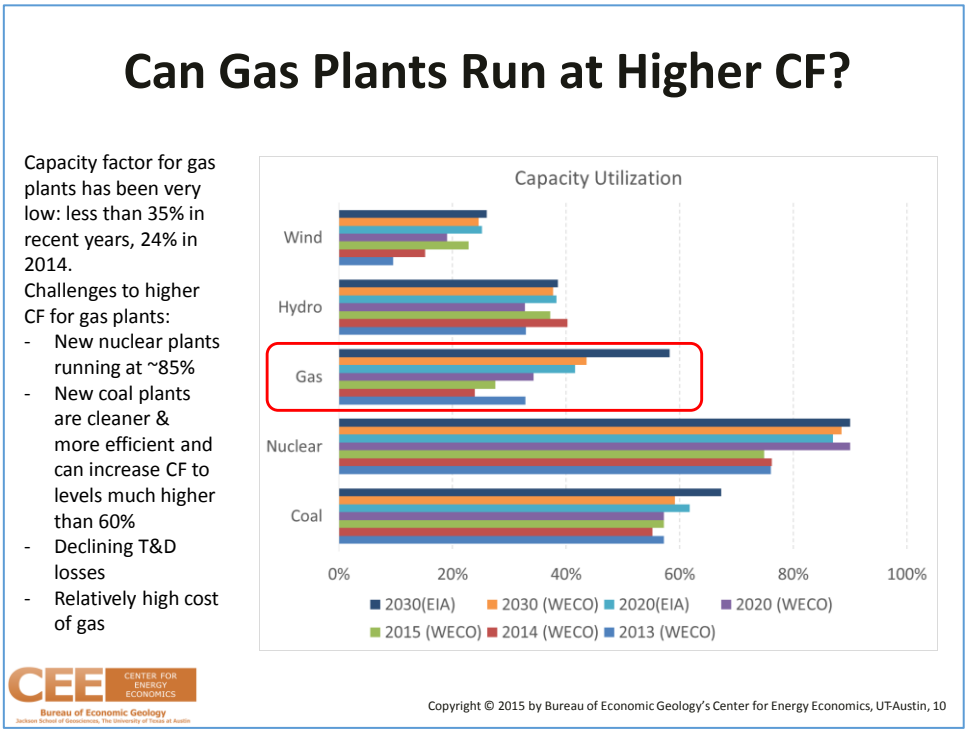


Source: EIA IEO 2013; BEG/CEE capacity factor analysis.

Given that capacity utilization has been very low for gas plants (Figure 8), probably owing to frequent cycling up and down to follow load, it is not likely that gas generators can maintain high efficiency. Capacity factors are assumed to improve in the future but much more in the EIA outlook than in WECO (Figure 8). However, a number of hurdles exist, in reality, to improving utilization of gas turbines. Not least of these is more efficient, new coal and nuclear units, with coal generation posing a distinct constraint on gas-fired power. Declining

losses on transmission and distribution grids and the higher cost of gas relative to coal – even without NDRC pricing policy influences – cloud the picture for gas generation output.

Figure 8. Capacity Utilization for Power Generation Sources in China



Source: WECO history and forecasts; EIA IEO 2013 forecasts; BEG/CEE capacity factor analysis.

With respect to natural gas for power generation, it will be affected both by overall electric power production and use and fuel competition. Growth in power consumption declined from 14.8 percent in 2010 to 5.6 percent in 2012, rose to 7.5 percent in 2013 and dropped to 3.8 percent in 2014. This uneven and ultimately lower growth is due to economic slowdown in China and lower industrial demand.

Gas use for power generation increased from 1 BCM to 30 BCM from 2000-2013, accounting for 18 percent of gas consumption and 42 GW of capacity at period end. Gas generation currently is located in the more affluent coastal regions, primarily for peak shaving. Under the 12th Five Year Plan gas generation is targeted to be 60 GW by 2015.

Natural gas and coal generators will compete intensely for market share, in keeping with the pattern in other countries. The OGT for coal generation was 25 percent lower than gas generation in 2013. Natural gas prices were increased in 2014 and then lowered 5 percent as of 1 April 2015 while coal prices continued to decline over the period.

Gas power generators have been incurring losses as they are used primarily for peaking with low annual utilization hours. At the end of 2012, 90 percent of China's coal generation plants were equipped with desulfurization units and denitrification continues.

The Chinese government is 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. Most current gas generation is in the coastal south and so new capacity will be required in the north.

Going forward China appears to be focusing on coal-fired, hydropower and nuclear generation for base load power generation. Nine large scale coal power bases are being developed in the west along with the construction of at least twelve new ultra high voltage transmission lines from west to east. Twenty-five nuclear units are under construction per the International Atomic Energy Agency (IAEA) and China's 2020 target for nuclear capacity is 58 GW, up from 20 GW currently.

According to Zhenya Liu (2013), Chairman of the State Grid Corporation, natural gas "should be mainly used for everyday use, industrial fuel and a raw material in the chemical industry." Once these needs are met, gas power generation can be developed at a "moderate pace" for peak shaving. Chairman Liu forecasts 70 GW in 2020 and 100 GW in 2030 for low utilization gas-fired peaking generation.

In sum, electric power is vital to China's overall energy and economic dynamic and natural gas is an alluring generation fuel. The potential for power generation to serve as a large "sink" for natural gas could be constrained by utilization of the gas generation fleet, a result of underlying factors affecting the cost and competitiveness of gas as a generation option.

Industrial Transitions and Gas Implications

Our focus mainly is on non-residential use and, in particular, industrial use given the dominance of industries in both gas and power consumption. With 49 percent of direct gas use and 76 percent of electric power use, Chinese industry is a big player. But this largest segment affecting natural gas and total energy demand in China also is undergoing deep and necessary transitions. Many of China's capital intensive industries are characterized by massive excess capacity, high debt levels, declining domestic demand, weak profitability and reliance on central and local government subsidies, including subsidies of electricity and natural gas costs.

Some industries, such as steel and glass, are significantly increasing exports resulting in record trade conflicts and trade remedy investigations in the EU and U.S.

The current Chinese government is attempting to transition the economy from a heavy industry oriented and export driven economy to a services oriented and consumer driven economy. Massive capacity reductions are required in many industries creating jobs, pensions and social unrest issues.

In October 2013 the State Council singled out steel, flat glass, cement, aluminum and shipbuilding as having "dangerous levels of overcapacity". In March 2014 it announced

measures to reduce production capacity in these industries for economic and pollution related reasons.

However, there has been limited success with production capacity reduction measures as local governments, which want revenue and jobs from the plants, do not implement the central government's orders.

Subsidies to Chinese industries can be placed in context of overall leverage that the Chinese government currently is working to mitigate. China's overall debt to GDP ratio was about 256 percent at the end of 2014. Most of China's outstanding debt is in the corporate sector. About 90 percent of the 2,400 companies listed in China received government subsidies in 2012 with support concentrated in heavy industry and manufacturing. Significant subsidies to industries are provided by heavily indebted local governments. The ability of these jurisdictions to continue current levels of funding may be limited. Sub-national debt loads are widely viewed to be contributing to the current debt to GDP ratio.

Excluding fertilizer plants (see later section on chemicals) large industries will be allowed to directly negotiate gas supplies and prices with producers, pipelines and LNG importers. Distribution bypass can occur. Price subsidy evidence indicates that many industrials do not pay the full regulated rate.

Following is our review of four major gas and energy consuming industrial segments: steel, chemicals, glass and paper.

Steel

China's steel industry suffered razor thin margins 2011-2013 due to raw material costs and overcapacity. Producers enjoyed a mild margin increase in 2014 due to lower iron ore and coking coal prices but fundamentals remain weak. Private steel producers accounted for 76 percent of capacity in 2013. Forty-one percent of domestic steel demand has come from real estate construction which slowed significantly in 2014. Steel demand from autos, 7 percent of total demand, is more resilient. Specialty steel production commands higher prices and margins. In 2013 specialty steel accounted for only 6.1 percent of China's total crude steel output. Specialty steel requires more advanced technology and production facilities and large capital investment.

Reuters reported that a fifth of China's 33 listed steel mills received government subsidies accounting for more than half of their profits in the first half of 2014 (Blenkinsop, 2015). Energy subsidies alone (coking coal, thermal coal, electricity, natural gas) were $27 billion from 2000 to 2007.[2]

As domestic demand for steel has slowed, steel exports have increased significantly. Protests from the EU and the U.S. have increased as well. The EU is expected to impose

[2] Historical subsidy figures here and elsewhere from *Subsidies to Chinese Industry* by U. Haley and G. Haley, Oxford 2013.

25 percent tariffs on Chinese steel imports. U.S. steelmakers filed 38 trade cases in 2013 and preliminary tariffs are to be imposed in May 2015.

Chemicals

Chemicals manufacturing, particularly fertilizers, constitutes the next major component of industrial demand. About 25-30 percent of urea producers are natural gas based and are located in China's northwest and southwest with one large SOE, China Blue Chemical, located in southern Hainan. Urea production is characterized by chronic overcapacity with downward pressure on domestic prices. Utilization rates of urea plants were less than 70 percent in 2014. As in the steel industry, China is addressing overproduction by increasing urea exports which were up 65 percent in 2014 and are expected to grow 20-30 percent in 2015. With respect to internal use of urea, long term agricultural demand is expected to be stable.

Natural gas and electricity prices for urea producers are administered by the government and have historically been the lowest of any sector in the country. In April 2015 the natural gas price to the fertilizer industry is to increase by Rmb.2/cm which is 50 percent of the price increase implemented for other non-residential consumers in 2014. This continued discount takes into account the downturn of the fertilizer market.

Railway tariffs will be increased in March 2015 hurting producers without coastal port access. Smaller, high cost urea producers are expected to continue to close down 5-6 percent of total capacity per year offsetting expected capacity growth of 3-4 percent per year.

Glass

China became the largest global producer of glass in 2009 with over 31 percent of global glass production and has the largest number of float glass production lines in the world. The glass industry exhibits strong geographic fragmentation with manufacturers in 29 of 32 provinces. The glass industry has a few large-scale companies with diverse product offerings but most companies produce low quality products on a small scale. Raw glass makers are not profitable at current price levels. Glass manufacturing is characterized by excess capacity and declining domestic demand due to reduced construction in the housing sector.

The float glass industry needs sustained improvement in property sales to boost construction and glass demand as well as a reduction in capacity. Total float glass capacity dropped about 5 percent in 2014.

Auto glass and other specialty glass products have the best profit margins and growth prospects.

In total, the glass industry received at least $30.3 billion in subsidies from 2004-2008 and subsidies continue today.

The natural gas price reduction effective April 2015 should improve profitability.

Paper

In 2008 China became the world's largest producer of paper and paper products. The industry is highly fragmented with over 8,000 companies, about 88 percent of which are small, operating in 30 of 32 provinces. Most of these companies manufacture low quality products with the exception of two large SOEs, Nine Dragons and Lee & Man. The industry suffers from excess capacity which has lowered domestic prices. Improved profitability requires both accelerated capacity closures and reduced capital expenditures.

Paper for industrial use accounts for about 60 percent of domestic paper demand. Paper demand growth has slowed as industrial production growth has declined.

Increasing environmental costs have caused small paper mills to close down. In Guangdong province the government is phasing out 5 million tonnes of low efficiency, high pollution and high energy consumption paper mill capacity by year end 2015. Larger mills will have to upgrade their nitrogen oxides (NO_x) and particulates emissions reduction equipment to meet more stringent standards by year end 2015. Many banks have stopped or restricted lending to paper mills with pollution problems. Government subsidies to paper mills totaled $33 billion from 2002-2009 and continue today.

Conclusions

Industrial gas demand more than tripled from 19 billion cubic meters (BCM) to 60 BCM from 2000 to 2013 even with an increasing gas price. Secondary industrial consumption of electricity increased by 71 percent between 2005 and 2012 and tertiary industrial consumption more than doubled despite the large cross subsidies from those sectors to households and agriculture. And yet, broad implications exist for Chinese natural gas and total energy demand based on our analysis of the power and industrial demand "wedges" and pricing policies.

At this stage our in-depth look at demand for natural gas in China leads us to observe the following.

- The power generation sector's needs for natural gas can be curtailed significantly owing to several factors:
    - Expected growth in new, more efficient and cleaner coal plants, nuclear facilities and renewables, including hydro, wind and, to a lesser extent, solar.
    - Continued decline in electricity intensity of the Chinese economy.
    - Slower demand growth resulting from a maturing economy and peaking population.
    - Challenging economics of running gas plants at low utilization rates.

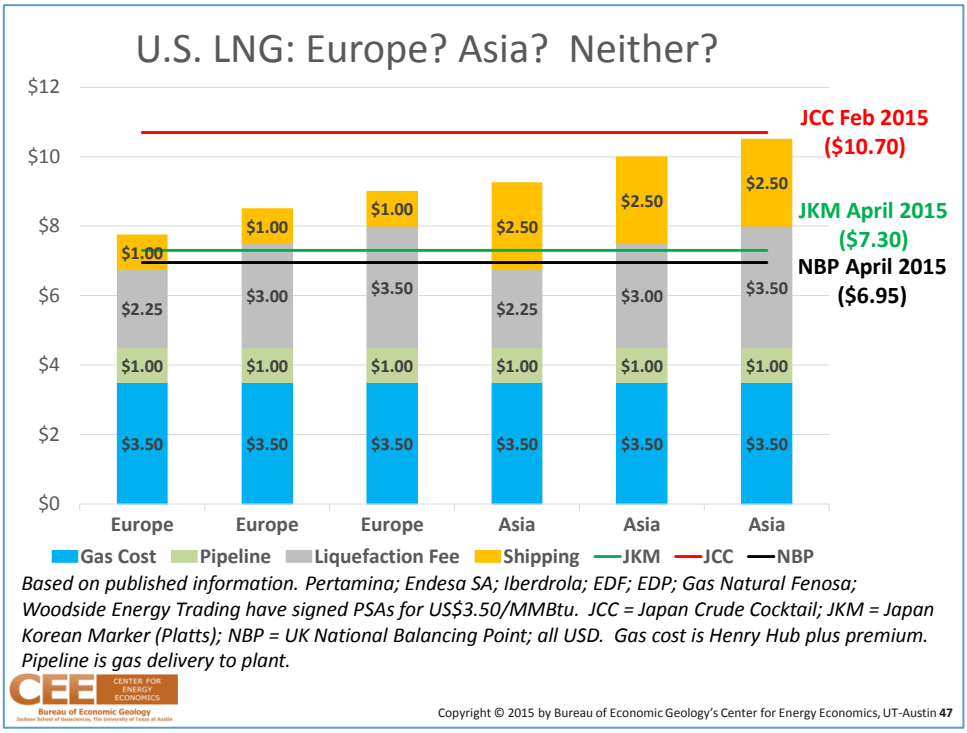
- The industrial sector's needs for natural gas can be curtailed owing to several factors.
  - Reforms of favourable pricing policies.
  - Modernization and more energy efficient industrial facilities and processes.
  - Elimination of excess and unprofitable industrial capacity, resulting in a lower growth, albeit more efficient and productive, industrial complex.
  - Potential switch to less energy-intensive services across the Chinese economy.
  - Competition from cheaper energy sources (e.g., electricity from coal and nuclear plants).

Mitigating circumstances to these preliminary observations exist, of course, not least in how provincial governments respond to national policies. Barring those, China gas demand will likely grow by much less than consensus projections over the next two decades or so. Both the power sector and industry face significant headwinds in developing more gas. Residential and commercial could be promising but will require a strong push to get local distribution infrastructure in place.

A Final Note on Gas Supply

While our study is demand focused, work-in-progress results bear many consequences for natural gas supply and trade flows. While China remains committed to domestic natural gas supply development, Chinese production is unlikely to meet even conservative demand projections. Meanwhile, negotiations continue and milestones have been announced for Russian gas flows to northern China. Russian gas is widely anticipated to satisfy northern Chinese gas demand, as outlined for power generation and CHP above. Finally, the third major supply source, liquefied natural gas or LNG, has been under development in China's major coastal cities and industrial and trade centers. The Chinese have proven to be adept commercial negotiators for contracted supply and pricing. As noted earlier, gas prices in coastal locations will be higher, in order to attract LNG cargos, and a geographic cross-subsidy exists and will persist with higher income coastal populations subsidizing lower income users in the interior. Along with the many other transitions in Chinese energy and economy are regional transitions in LNG contracting, shipping and risk management (Figure 9 below). While slow to emerge, short term LNG sales and shipments and ongoing discussions regarding an LNG futures contract, hub, and/or other developments are gaining increased attention. In the least, China's entry and stepped up participation and recent commodity price gyrations have accelerated evolution of a more competitive Asia-Pacific basin. The extent to which LNG suppliers can withstand stiffer competition and aggressive customer pricing will dictate to a large degree how large the supply base might be to support Chinese gas demand. Implications for the supply side are that competition to supply China may be long-lasting, and if Russia can execute a negotiated supply arrangement, LNG suppliers may have to look to other markets to support new projects.

Figure 9. U.S. LNG in A More Competitive Asia-Pacific[3]



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[3] At some point, liquefaction could be considered sunk cost to achieve a lower marginal cost for liquefaction.

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