U.S. EPA Coalbed Methane Outreach Program

Energy Markets in China and the Outlook for CMM Project Development in Anhui, Chongqing, Henan, Inner Mongolia, and Guizhou Provinces

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Acronyms and Abbreviations

AC	Alternating Current
C	Carbon
CBM	Coalbed Methane
CCER	China Certified Emission Reduction
CDC	China Datong Corporation
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CHP	Combined Heat and Power
CMM	Coal Mine Methane
CMOP	Coalbed Methane Outreach Program
CNG	Compressed Natural Gas
CNOOC	China National Offshore Oil Corporation
CNPC	China National Petroleum and Gas Corporation
CNY	Chinese Yuan (currency)
CO_2e	Carbon Dioxide (CO_2) Equivalent
CPGC	Central China Power Grid Company
CPIC	China Power Investment Corp
CQEIG	Chongqing Energy Investment Group
CSPGC	China Southern Power Grid Company
DC	Direct Current
ECPG	East China Power Grid
EIA	United States Energy Information Administration
FGD	Flue Gas Desulfurization
GDP	Gross Domestic Product
GMI	Global Methane Initiative
GW	Gigawatt
HEC	Henan Electric Company
HIG	Henan Investment Group
IMPGC	Inner Mongolia Power Grid Company

kcal	Kilocalorie
kg	Kilogram
kJ	Kilojoule
km	Kilometers
kV	Kilovolt
kWh	Kilowatt Hour
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
m	Meters
M2M	Methane to Markets Partnership
m^3	Cubic meters
MEP	Ministry of Environmental Protection
mm	Millimeters
mmbtu	Million British Thermal Units
mmkWh	Million kilowatt hours
MPa	Megapascal
$MtCO_2e$	Million tonnes Carbon Dioxide Equivalent
MW	Megawatt
MWh	Megawatt hours
NA	Not applicable
NDRC	China National Development and Reform Commission
NEA	China National Energy Administration
NEIMPGC	Northeast Inner Mongolia Power Grid Company
SCEC	Songzao Coal and Electricity Company
SERC	China State Electricity Regulatory Commission
SGCC	State Power Grid Company of China
SPC	China State Power Corporation
t	Tonnes
tCO_2e	Tonnes Carbon Dioxide Equivalent
tpy	Tonnes per year

TWh	TeraWatt Hour(s)
UHV	Ultra-High Voltage
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
USEPA	United States Environmental Protection Agency
VAM	Ventilation Air Methane
VAT	Value Added Tax

1. Executive Summary

1.1 Introduction

This document reports the results of energy market analysis performed during the course of several comprehensive coal mine methane (CMM) recovery and utilization feasibility studies conducted in China. These studies were conducted as a part of a larger initiative funded by the United States Environmental Protection Agency (USEPA) under the Global Methane Initiative (GMI), formerly the Methane to Markets Partnership (M2M). USEPA's Coalbed Methane Outreach Program (CMOP) has launched five full-scale feasibility studies of coal mine methane recovery and utilization projects at Chinese coal mines. The information in this study comes from five published feasibility studies: Feasibility Study of CMM Utilization for Songzao Coal and Electricity Company Coal Mines (May 2009), Feasibility of Improved Coal Mine Methane Drainage and Use at the Mines of the Hebi Coal Industry (Group) Corporation, Limited (2010), Feasibility Study for CMM Drainage and Utilization at Liuzhuang Coal Mine, Huainan Coal Field (February 2010), Feasibility Study of CMM Utilization for Guizhou Nengfa Power Fuel Development Co., Ltd. Linhua Mine Located in Guizhou Province (December 2010), as well as the Feasibility Study for CMM Drainage and Utilization: Inner Mongolia Tai Xi Group Mines (December 2011). The published studies can be found at http://epa.gov/cmop/international/china.html.

1.2 Coal Market

Coal dominates China's energy market with an estimated 69 percent contribution to energy needs in 2011 (EIA, 2014). EIA envisages coal's share of the total energy mix to fall to 63 percent by 2020 and 55 percent by 2040 due to anticipated increased efficiencies and China's goal to increase it's environmental sustainability; however, absolute coal consumption is expected to double over this period, reflecting the large growth in total energy consumption due to economic growth (EIA, 2014). China plans to reduce carbon emissions per unit of gross domestic product (GDP) by at least 40 percent from 2005 levels by 2020. China has also announced plans to reduce its energy intensity levels (energy consumed per unit of GDP) by 16 percent between 2010 and 2015 and increase non-fossil fuel energy consumption to 15 percent of the energy mix by 2020 (EIA, 2014). **Figure 1** shows estimates of various components' contributions to China's energy mix as estimated by the US Department of Energy's Energy Information Administration (EIA).

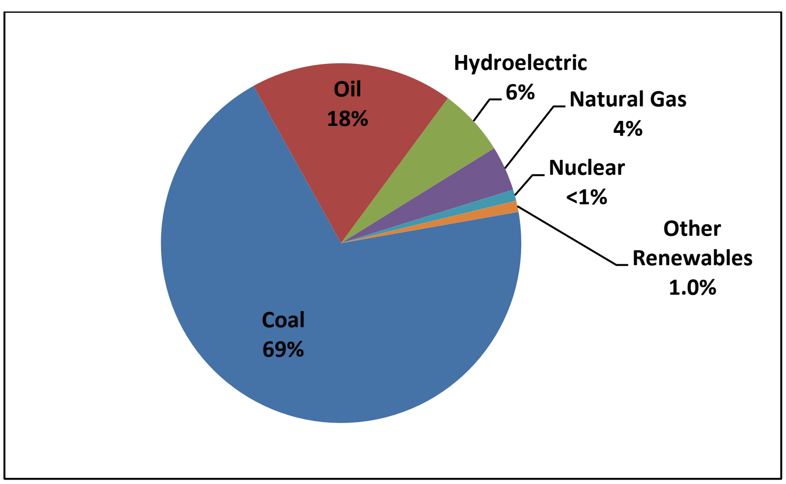

FIGURE 1: CHINA'S ENERGY MIX
Source: EIA (2014)

Domestic coal production and transport capacity has strained to keep pace with demand in recent years, with output rising by only 3.6 percent from 2011 to 2012 (**Figure 2**).

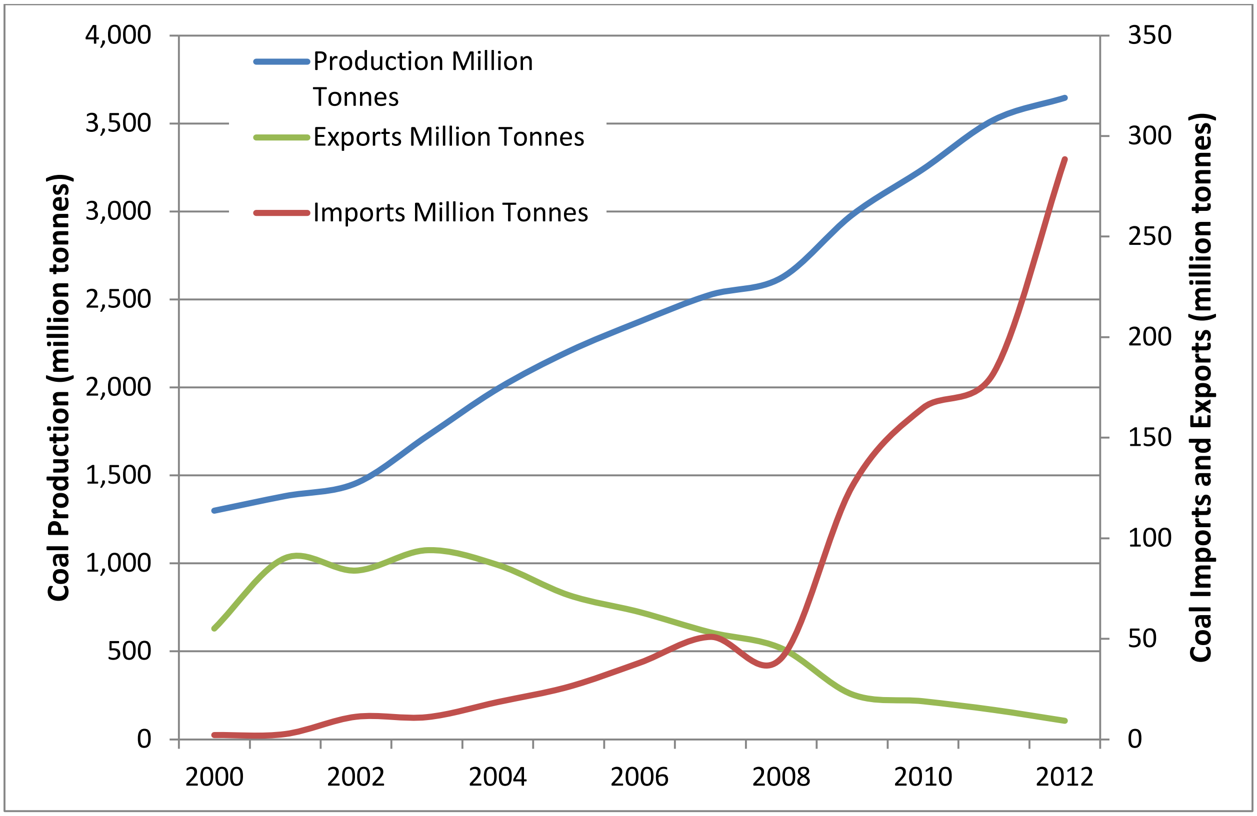

FIGURE 2: CHINA'S RAW COAL SUPPLY
Source: CESY (2013) p. 11, 36

As a result, China has been transformed from a net coal exporter into the world's largest importer, with net imports reaching 168 million tonnes, or 4.8 percent of total consumption on a physical quantity basis, and over five percent on a heat value basis in 2011. Imports are consumed primarily in the southern and eastern coastal cities, the primary victims of coal transportation bottlenecks, and in steel mills. Thermal power generation has been the most important driver for coal industry expansion, accounting for approximately half of total consumption in recent years, followed by steel and cement, which have accounted for about 25 percent of the total.

Growth of coal consuming sectors has averaged 11-11.7 percent from 2006-2011, 6.7-13.5 percent higher than economic growth itself. The exception to this pattern occurred in the second half of 2008 to the first half of 2009, when economic growth slowed to as low as six percent under the combined impact of the global financial crisis and government-mandated tightening of the real estate market. The investment-centered economy in China recovered quickly, however, as the global economy stabilized and the Chinese government implemented a four trillion CNY (625 billion USD) infrastructure-centered stimulus program. Previous patterns of growth resumed from the second half of 2009 through the end of 2011. Since the beginning of 2012, the Chinese economy has slowed once again under the combined impact of a foreign shock from Europe, Chinese government efforts to control inflationary real estate transactions, and the wrap-up of 2008-2009 stimulus spending.

The World Bank projects overall growth at about 8.5 percent from 2011-2015, but with a gradual transition from investment-heavy, industry-led growth (down to 40 percent of total GDP by 2015) towards a more significant role for consumption (up to about 55 percent by 2015) (World Bank, 2012). If coal-fired power generation increases by 7.5 percent per year and unit coal consumption decreases by five percent over the entire 2011-2015 period (i.e., slightly less than one percent per year), coal consumption in the power industry would increase by about 6.4 percent.

Output of coal by classification in 2010 was approximately as follows (**Figure 3**):

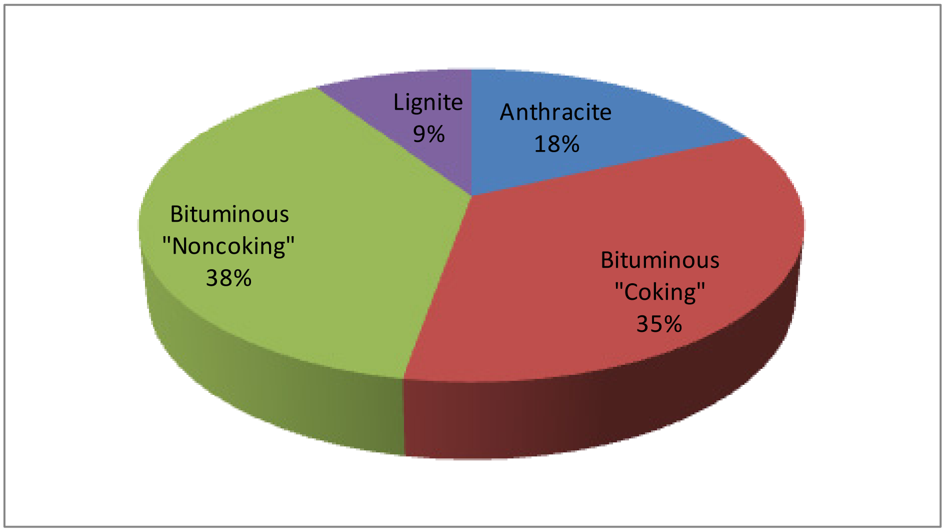

FIGURE 3: OUTPUT OF COAL BY CLASSIFICATION, 2010
Source: Gaoping Coal Beneficiation Association (2010); Industrial Futures (2011)

China's coal reserves and production are disproportionately concentrated in the north-eastern and central part of the country as shown below in **Figure 4**.

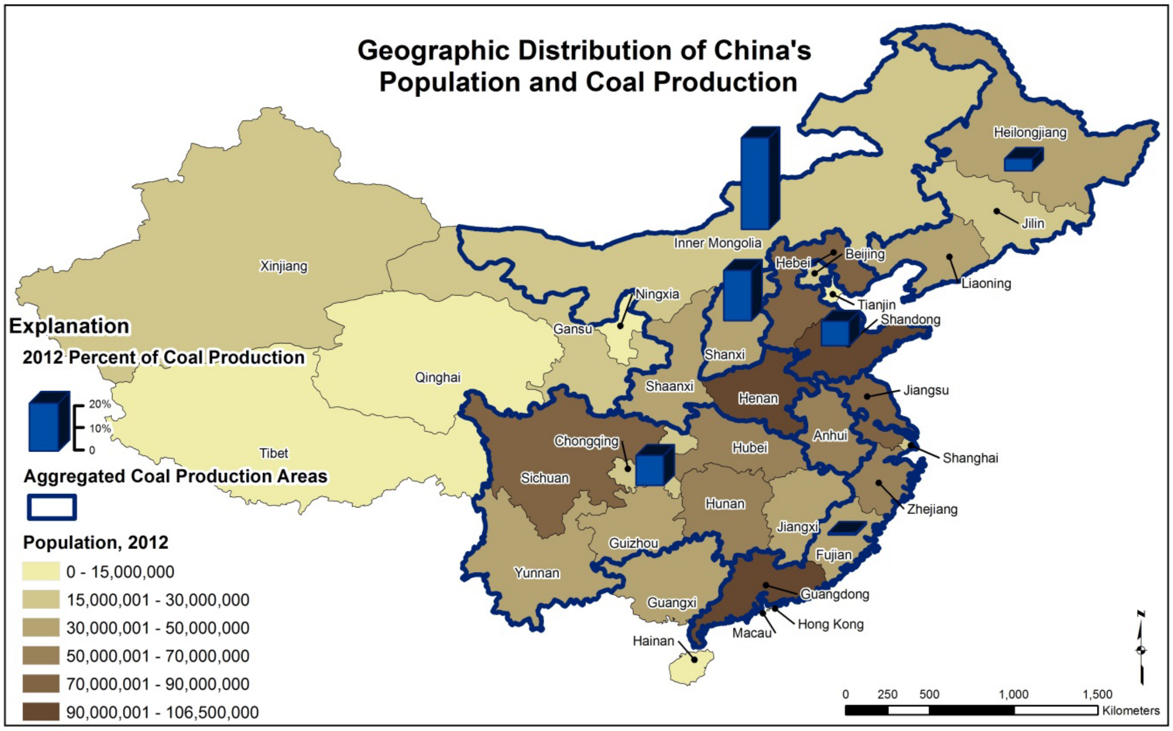

FIGURE 4: GEOGRAPHIC DISTRIBUTION OF CHINA'S COAL RESERVES AND PRODUCTION

Source: CESY (2013)

As the heavy industrial economy boomed, coal producers enjoyed a seller's market starting from the end of 2009 through the beginning of 2012 as market prices increased at double digit rates. The slowdown in thermal electricity, steel, and cement sales in the second quarter of 2012 caused the free market delivered price to collapse, as coal stockpiles throughout the country soared.

1.2.1 Provincial Coal Markets

China's macroeconomic slowdown of 2012-2013 and the end of the 10-year coal boom market has had a profound effect on Anhui's coal industry. Province-wide output in 2013 was 12.5 million tonnes, or 8.3 percent lower than in 2012. After increasing at double digit rates for most of the 21st century, coal consumption in Anhui only grew at an average rate of 4.2 percent during 2011-2012. The slowdown in the industrial (non-utility) sector was particularly noteworthy, with consumption actually declining in absolute terms in 2010, and growing at only 3.5 percent in 2011-2012, despite double digit growth in traditional consuming industries such as cement. Consumption in coke ovens likewise declined even as pig iron output increased. Only in the utility sector, which accounted for 54 percent of Anhui's coal usage in 2012, was the 9.5 percent growth rate from 2010-2012 comparable to earlier years.

Historically, the difficulties of transporting coal over the mountains from the north have forced Chongqing to rely primarily on its own coal production, despite the limited size, complex geology, high recovery costs, and mediocre quality of the municipality's high sulfur anthracite deposits. Starting from 2008, Chongqing became a progressively larger net coal importer as its own production plateaued. Most incoming coal originated in Shaanxi Province to the north, with the remainder coming from Guizhou to the south.

Chongqing was hit hard by the deceleration of economic growth throughout China in the first half of 2012. As demand for power and heavy industrial commodities moderated, its coal mines are no longer able to sell all their output, and losses have mounted. Part of the slump is cyclical. When the shorter term causes (Western European recession, cutback in domestic real estate transactions, cyclical aspects of the growth) are removed, growth in coal consumption will resume.

Coal production in Henan, one of China's oldest coal producing regions, contracted by 77 million tonnes, or a factor of one third, between 2009 and 2013, as the province became a major net coal importer for the first time. Like other producers from long-established mining areas, Henan mines are not cost competitive with the flood of new mines coming on-stream from new mining areas in Shaanxi and Inner Mongolia.

Guizhou has traditionally been a coal exporting province, shipping 25-30 million tonnes to outside customers in recent years. The Guizhou Coal Bureau has projected in-province demand growth at 11.5 percent per year from 2010-2015 to approximately 170 million tonnes, driven largely by electric power plant construction. Guizhou's coal quality also makes it relatively attractive to neighboring provinces and Guizhou is virtually the only source of coking coal in south and southwest China.

The stunning 13-fold growth in Inner Mongolia's coal industry from 2000-2011, which has earned it a 28 percent market share in China and catapulted its output beyond that of all countries outside of China, results mainly from the Chinese government's decision to make huge amounts of inexpensive capital available for exploitation of a number of almost virgin deposits. The Inner Mongolian coal boom has been driven primarily by demand in the Yangtze Delta and southern coastal provinces. Shipments outside the province grew at a 32 percent rate from 2005-2009. The overall economic slowdown and consequent collapse of the coal market boom throughout China in the first half of 2012 has affected Inner Mongolia severely, with many mines reducing production, or even shutting down part time. While it is safe to predict that Inner Mongolia companies will benefit more than higher cost, lower quality producers in other provinces when the slump ends, it is difficult to predict how quickly this will happen, and what the longer term changes in the pattern of demand for coal will be. The overall percentage of in-province consumption of Inner Mongolian coal dropped from approximately 54 percent in 2005 to an estimated 40 percent or less in 2011. Even with continued expansion of mine mouth generating capacity, provincial demand by itself will not be sufficient to sustain the explosive expansion of 2000-2011.

1.3 Electricity Market

China's electricity consumption grew at a robust average rate of 11.1 percent from 2005-2011. With the exception of 2008-2009, growth in electricity consumption surpassed overall economic growth by an average margin of 19 percent. In an investment-centered economy, industry was the primary driver of electricity, accounting for close to 73 percent of total consumption in 2012 (**Figure 5**). Metals, building materials, and chemicals alone accounted for 37 percent, with residential and commercial consumption accounting for only 17 percent.

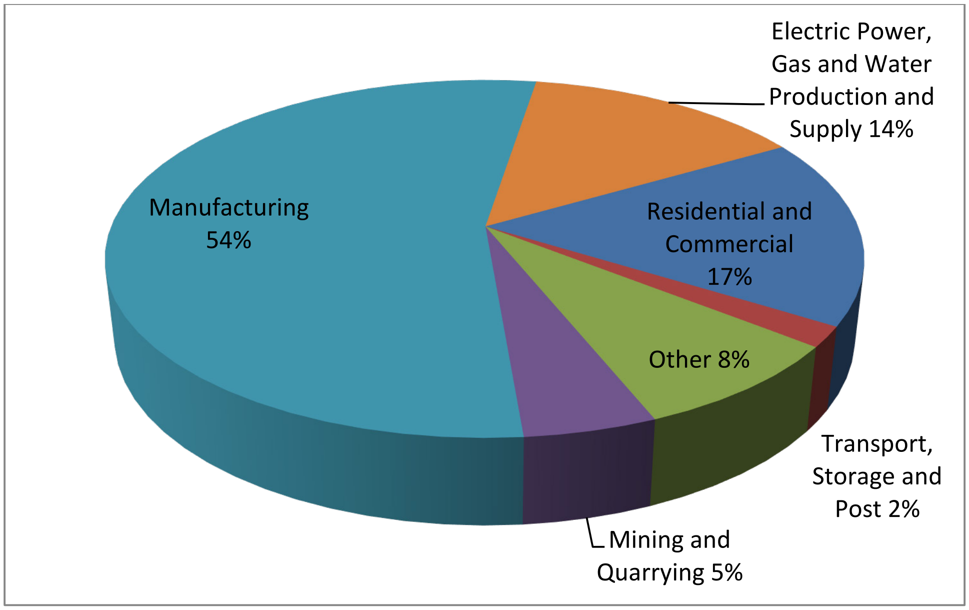

FIGURE 5: ELECTRICITY CONSUMPTION BY SECTOR, 2012
Source: CESY (2013) p. 87

As China is a zero importer/exporter of electricity, its growth has come entirely from domestic generation, with output and generating capacity increasing by an average of 11.1 and 12.5 percent annually from 2005-2011 to 4,700 Terawatt Hours, and 1,060 Gigawatts, respectively. Thermal power, overwhelmingly coal-fired, dominates the generation mix.

1.3.1 Provincial Electricity Markets

Anhui is an interior, more rural province whose economy modernized slowly. As it is also by far the largest coal producer in the East China region, regional and national planning authorities developed the so-called “Anhui power to the East” program in the mid-2000s with the explicit goal of transforming Anhui into a power supplier to the Yangtze Delta provinces of Zhejiang, Shanghai, and Jiangsu. Three, 500 and one, 1000 kV AC transmission lines with aggregate capacity of about 15,000 MW now connect Anhui to the Delta provinces. By the end of 2015, 12,000 MW of power plants will be in operation under the “Anhui Electricity to the East” program, with output fully dedicated to the Delta provinces. Since 2009, the Delta provinces have relied on external sources for about 15 percent of their electricity, with Anhui supplying approximately one third (an amount equal to over 20 percent of Anhui’s generation). Anhui’s domestic electricity consumption has recently continued to grow at double digit rates. In 2013, manufacturing/mining/construction services, and residential electricity usage rose by 11.3 percent, 16.5 percent, and 13.8 percent respectively. Anhui’s provincial leadership called for wider use of CMM, but without specific reference to the power sector in its energy five-year plan for 2011-2015. Possibly the growing attention to distributed power will raise CMM’s profile. From a supply and demand perspective, Anhui needs any power that CMM plants could provide.

Power consumption in Chongqing (including both centrally dispatched power from the Chongqing Power Grid Company and the approximately 10-15 percent coming from several smaller local grids) grew at a 12.6 percent per year rate from 2005-2011 to a level of 71,700 GWh. Chongqing’s economic and electricity consumption growth slowed down sharply in the first half of 2012 due the nationwide slump in real estate and the European recession. After these short term factors have passed, electricity consumption growth rates are likely to fall from 2005-2011 levels as the national economy reorients towards consumption. But growth could still average as much as 8-10 percent, higher than in the rest of China, due to the momentum of urbanization. Despite an aggressive investment program by the Chongqing Municipal government and the five national generating companies in the 2005-2011 period, which nearly doubled generating capacity and led to 13 percent per year growth in municipal power generation, Chongqing continued to depend on outside generation sources for 25 percent of its power supply. The Chongqing Municipal government has put forward a plan to double generating capacity within the city to 20,000 MW or more during the Twelfth Five-year Plan from 2011-2015.

Henan, located in North-Central China, is one of China's most populous provinces, with 94 million people counted in the 2010 census. While like most of China's interior provinces, its per capita income and urbanization rates have lagged behind the more developed coastal provinces, its GDP and electricity consumption growth rate kept up with the double digit national average in the first decade of the 21st century. Growth exceeded the national average in 2010 and 2011 as the focus of growth shifted towards interior provinces and the government loosened lending for capital projects to stimulate the economy and counteract the impact of the global economic downturn. Between 2012 and 2013, however, growth of the national GDP dropped in response to China's post-global downturn stimulus. Under these new circumstances, Henan's electricity consumption growth rate fell precipitously to 3.3 percent in 2012, and increased only modestly to 5.5 percent in 2013, a full two percentage points lower than the national average for both years. The overwhelming majority of the power generated in Henan is consumed in-province. Weak electricity demand in Henan in 2012-2013 resulted directly from the weaknesses of its heavy industry, and particularly from the weakness of its aluminum sector. Were electricity consumption in Henan to continue to grow at the rates of 2000-2011, it could be reasonably projected that power supply would fall short of demand looking forward from 2013. But if consumption in the metallurgical sector fails to bounce back, and electricity consumption increases at no more than six to seven percent per year, the combination of significant expansion in coal-fired generation and the infusion of power from a new transmission line from Xinjiang may be sufficient to fulfill the province's needs. The success of distributed power generation, whether from renewable plants or CMM generators, will therefore depend critically on enforcement of policy mandates for favorable dispatch.

The Guizhou power grid is one of five interconnected provincial grids which are controlled by the state-owned China Southern Power Grid Company (CSPGC). Although Guizhou is one of China's smallest, poorest, and least urbanized provinces, its interconnections with the rest of the country have grown stronger in recent years. As is the case for most inland provinces, Guizhou's economy has continued to grow at double digit rates throughout the second decade of the 21st century even as national economic growth has moderated. In a sharp break with past patterns, however, electricity consumption growth has trailed economic growth by increasing margins over the period, falling to 7.2 percent in 2013. Manufacturing remains the most important driver for economic growth in Guizhou, increasing at well over 10 percent per year and accounting for approximately 75 percent of total electricity consumption in the province. In continuation of an electric power investment boom initiated at the beginning of the 21st century in connection with a program to supply electricity to Guangdong, Guizhou's power generation capacity increased by about 17,000 megawatts, or 63 percent to almost 45,000 MW between 2009 and 2013. The expansion included major hydropower, as well as a number of large thermal power plants burning Guizhou's plentiful coal resources. As of the beginning of 2014, coal-fired plants accounted for 54 percent of total capacity and hydropower for 42.6 percent.

Power generation in Guizhou increased annually by an average of 5.4 percent between 2009 and 2012. While growth in power consumption has exceeded the growth rate of power generation, some installed capacity has not been commissioned and this has led to restrictions on power usage. If demand within Guizhou and Guangdong continues as projected, supply and demand for electricity within the larger region could be more closely balanced than in the past. There will continue to be considerable variability annually due to the unpredictability of water conditions; in bad water years, the Guizhou grid could dispatch every unit it produces, whereas in good water years, it may not fully dispatch the available coal-fired capacity. Given their lower wholesale prices, the hydropower plants will always enjoy priority for dispatch. The public grid could require all distributed power producers, including CMM power plants, to produce in low water years when hydropower is scarcer; even then, all CMM fueled powered producers may not be able to dispatch electricity some years if they are unable to meet or beat the cost of coal-fired power to the grid of approximately 0.38-0.39 CNY per kWh. Distributed generators will need to rely on enforcement of policy mandating favorable dispatch of their output.

Inner Mongolia is a significant net supplier of electricity to outside provinces based on its abundant coal resources, sparse population and modest internal demand, and relative proximity to the Beijing-Tianjin load center. The development of a series of large coal-fired plants such as the 4200 MW Datang Tuoketuo facility near the Zhonge'er coal mines (the largest coal-fired power plant in the country), has sparked a 19 percent per year growth rate from 2005-2011 which has made the formerly isolated frontier province an indispensable supplier to the North China grid area. Inner Mongolia has the potential to become an even more significant source of power to the rest of China based not only on its coal resources, but also on the wind power potential created by the Siberian winds sweeping across its sprawling grasslands and deserts. According to official estimates, it is technologically feasible to construct 130,000 MW of wind power capacity in Inner Mongolia, a significant proportion of which can generate at world-class utilization rates (Inner Mongolia Energy Bureau, 2011; China Electricity Council, 2012). Demand for power in Inner Mongolia itself increased at an 18 percent rate from 2005-2011, considerably higher than the national average as new generation facilities came online and the region's resource extraction economy accelerated. Potential coal mine methane power generators in Inner Mongolia will deal with power grid companies more experienced than in any other part of China in dealing with variable supply from small power suppliers; however, as a practical matter they will have to compete with the wind power plants for dispatch in a province that has a much stronger stake in wind power than in CMM.

1.4 Gas Market

In 2011, coal continued to supply 69 percent of China's energy needs despite multiple central government urgings and projections for its share to decline. Conversely, despite years of double digit growth in the gas industry, natural gas fueled power accounted for about 4.6 percent in 2011 (EIA, 2014). Being considerably cheaper to produce than natural gas, coal will remain the dominant power source into the future, but the Chinese government is looking increasingly to mitigate the health and environmental problems associated with pollution from coal burning (especially in cities) by actively promoting the use of cleaner energy options, such as natural gas and coal mine methane. The National Energy Administration's Draft Natural Twelfth Five-year Gas Development Plan issued in mid-2012 called for the natural gas percentage to reach about 8 percent by year-end 2015, and there has been speculation that it could rise as high as 12-15 percent by 2020.

The natural gas market in China has experienced a surge of historic proportions since the turn of the century. This has been a result of the government's decision to invest billions in production facilities, long distance pipelines and liquefied natural gas (LNG) receiving terminals in order to introduce natural gas into the major eastern and southern coastal population and industrial centers. Gas consumption has grown at a sustained 17 percent rate since 2000, far in excess of original official expectations as consumers of all kinds experience the benefits of a clean, convenient fuel.

The government now projects that consumption will double to 260 billion cubic meters in 2011-2015, and to 350 billion cubic meters in 2020 (still only about 10 percent of 2011 worldwide total), and it is making commitments to import ever larger quantities of gas from outside of China to fulfill this goal as China's domestic production fails to keep up with demand (People's Daily Net, 2012).

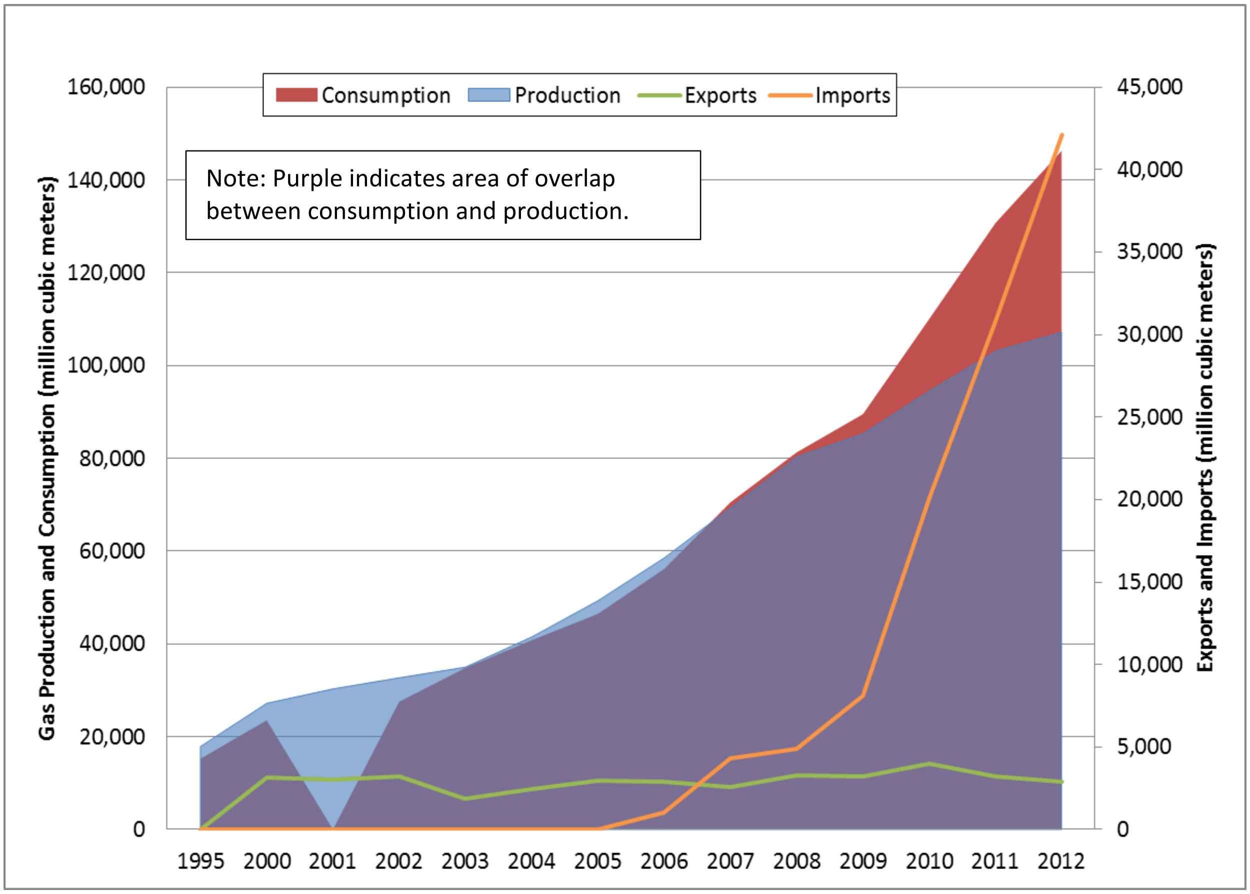

FIGURE 6: CHINA NATURAL GAS MARKET DEVELOPMENT, 1995-2012

Source: CESY (2013) p. 11, 43, 96

Natural gas consumption in China is driven primarily by residential and commercial use, the chemical/fertilizer raw material industry, as well as industrial use. Secondary consumers are electric power generation, automotive, and cement manufacture. China's natural gas consumption by sector is shown in **Figure 7** below.

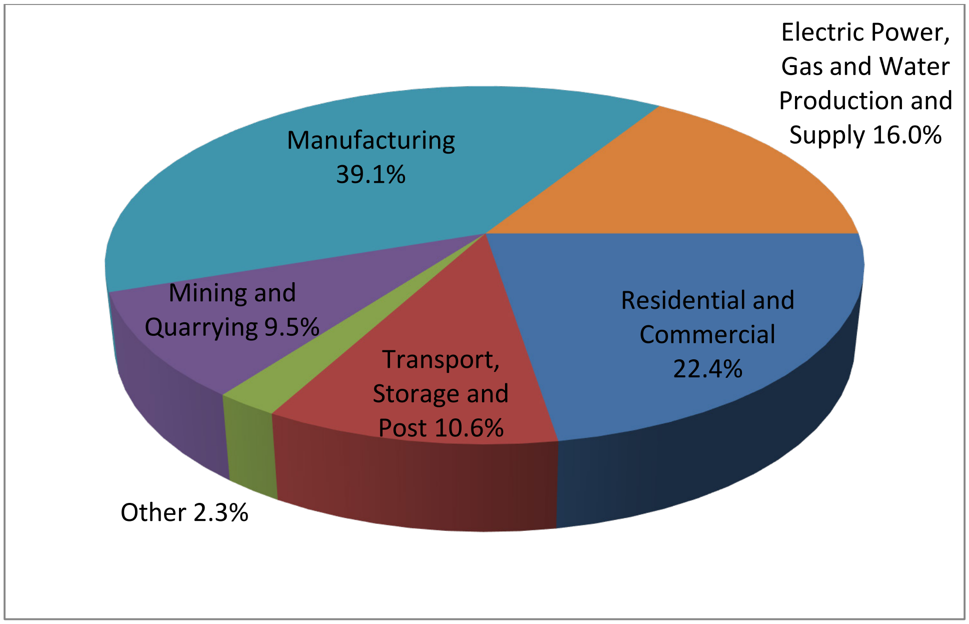

FIGURE 7: CHINA'S NATURAL GAS CONSUMPTION BY SECTOR 2012
Source: CESY (2013) p. 84

Figure 8 shows China's urban population with access to natural gas by province in 2012.

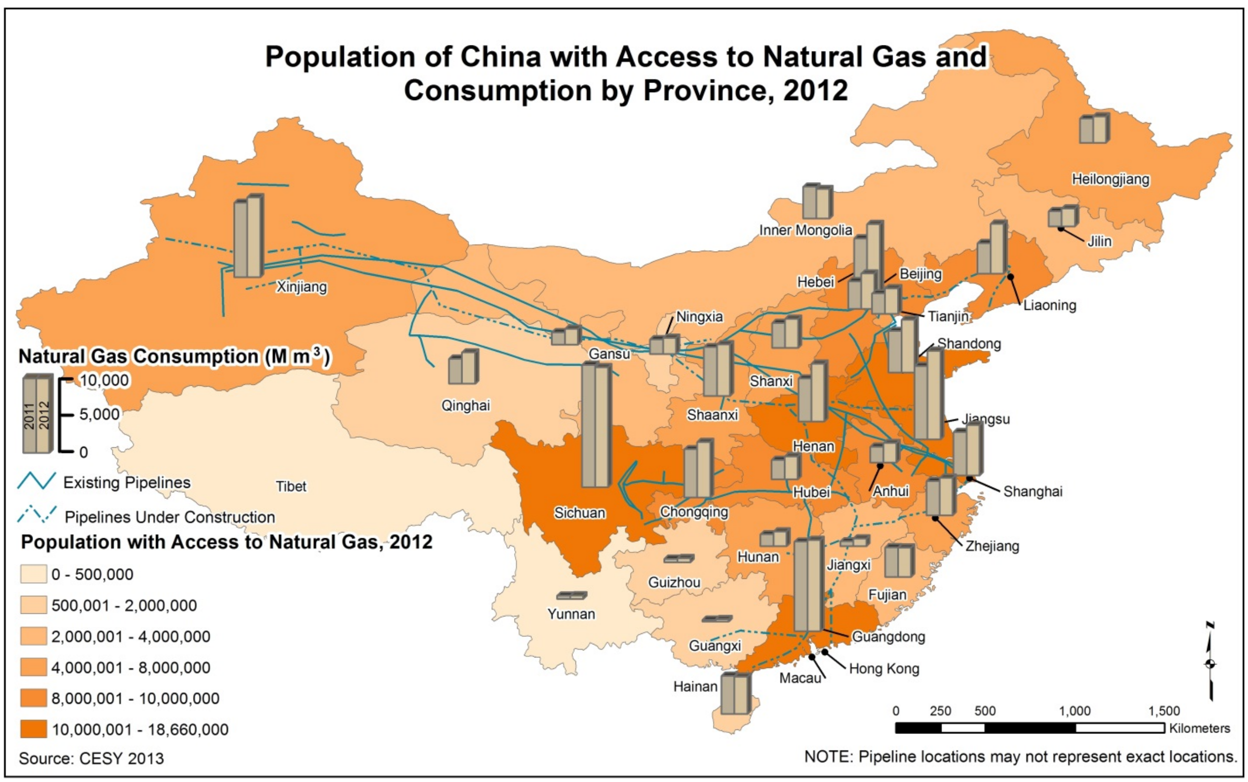

FIGURE 8: POPULATION OF CHINA WITH ACCESS TO NATURAL GAS AND CONSUMPTION BY PROVINCE, 2012
Source: CESY (2013) p. 47

1.4.1 National Policy for CBM and CMM Development

The implementation of the Clean Development Mechanism (CDM) in 2005 brought the promise of carbon credit revenue and increased interest in utilization of CMM. Soon afterwards, the Chinese central government promulgated its own incentives for CBM and CMM producers, including a 0.20 CNY per cubic meter payment for CMM consumed as a household or industrial fuel, and an approximately 50 percent price premium over coal for power sold to the public grid. The grid companies, furthermore, were directed to provide favorable dispatch to the CMM generators (MOF, 2007; NDRC, 2007.4).

As a result, 92 CMM projects have been prepared for the CDM (Huang, 2014). Coal mining companies installed a reported aggregate 750 MW of distributed power plants to burn CMM (including the 120 MW plant at the Jincheng Coal Mining Company in the Qinshui Basin, the world's largest CMM power plant), and the number of CMM household and industrial customers rose to 1.89 million (NEA, 2011). Nonetheless, CMM utilization lagged far behind production given the limitations of local utilization infrastructure, and the failure of CMM to penetrate the larger natural gas market. The incentive program for CMM power plant utilization proved particularly difficult to implement due to resistance from power grid companies uneager to manage the complexities of dispatch of the fluctuating output of small CMM plants, and lacking a policy mechanism to pass the premiums through to consumers.

CBM and CMM have gradually evolved from a pure mine safety concern to a significant component of natural gas development in the government's Twelfth Five-year Plan. The degree of actual integration of CMM into the natural gas economy will depend on continuing demand-side pressures, the favorability of the regulatory environment, and the quality of management of CMM operation by the mines themselves.

The Twelfth Five-year Plan on CBM/CMM calls for CMM to be used primarily as a local fuel, with the number of residential users to double to about 3.3 million households between 2010 and 2015, and power generation capacity to quadruple to 2850 MW as overall CMM utilization rises by about 5.5 billion cubic meters. The challenges to meeting this target are significant.

It will be necessary to improve CMM drainage practices to raise the average methane content of the CMM, given the difficulties and expense and inherent danger of transporting low-concentration methane. Of the approximately 7.5 billion cubic meters of CMM drained in 2010, a significant majority was less than 30 percent methane concentration.

A series of regulations put forward by the National Energy Administration and the China Ministry of Environmental Protection (MEP) attempt to deal with the problem. But at least through mid-2012, there was anecdotal evidence that an MEP-issued regulation in 2008 requiring operators of CMM drainage systems with greater than 30 percent methane concentration to use or flare the gas was creating a perverse incentive in some areas to maintain gas concentrations below 30 percent, ignoring best practices and safety standards.

The focus on local consumption of CMM poses additional challenges, as many of the coal mines recovering CMM have exhausted the possibilities for burning the CMM to generate power for their own use, or supplying CMM to customers in the immediate vicinity of the mines. Only a few local governments such as Jincheng, a municipality of approximately two million people (perhaps 10 percent actual urban residents) in the Qinshui basin area, have mobilized to invest in region-wide CMM distribution infrastructure.

The purification and liquefaction of CMM offers a potential solution to the market barrier problems. Technologies to remove impurities of CMM at low temperature have been proven outside of China, and are under development in China itself; no extra step is required to liquefy once purification has taken place.

While it would most likely not be economic to sell the product to the petroleum pipeline companies given the domestic gas pipeline transmission pricing structure, transportation by tanker truck would allow the CMM plants to sell directly to near or distant distribution companies. They would have the freedom to seek markets in the relatively wealthy southern coastal areas which depend almost exclusively on imported gas with which CMM is likely to be more cost competitive (3-3.5 CNY per cubic meter delivered to citygate), and which have shown a willingness to absorb higher prices.

Given the modest size of the plants and the variability of CMM flows, the plants would likely sell primarily to the spot or peaking markets. If liquefied CMM accounted for only a small proportion of supply in a particular region, even distribution companies in less wealthy areas might also be able to absorb its higher cost relative to domestic pipeline gas.

Liquefied CMM would also likely be cost-competitive with methane produced at coal-to-gas plants transported by pipeline, which the government is considering as part of the Twelfth Five-year Plan for natural gas. Media reports suggest that these costs would be as high as 2.1 CNY per cubic meter.

Large-scale development of shale gas, on the other hand, could lower the cost structure of the national gas industry as it has in the United States, working against the interests of CMM producers. Given the time required to develop shale gas expertise and build the pipelines necessary for transport of product to market, this is likely to be a long-term rather than a medium-term issue. In general, the economics of purified and liquefied CMM should be attractive under conditions where overall supply continues to be tight, and imported gas is a significant component of the overall natural gas sales base.

While many coal mining companies have considered the LNG option for utilization of their CMM, most have hesitated to move ahead in view of the high up-front cost relative to other options such as small distributed power plants, and the lack of reference CMM LNG units in China. As of mid-2012, only small demonstration facilities constructed by Chinese purification technology developers were in operation.

The Twelfth Five-year Plan calls for development of CMM purification/LNG plants to an “appropriate degree”. The first industrial-scale facility, a 100 million cubic meters per year plant (100 percent methane basis, with extracted CMM at approximately 40 percent) developed by the Chongqing Energy Investment Group’s Songzao Coal and Electricity Corporation under construction is due in operation in 2013. The success of this flagship project would stimulate the development of a number of additional facilities in coal mining areas that produced a sufficiently high volume of medium-concentration CMM; however, Chongqing’s low prevailing gas wholesale and retail prices may pose economic challenges for purification facilities such as Songzao’s.

1.4.2 Provincial Markets for CMM

In Anhui, the cities of Huainan and Hefei have a number of commercial and industrial plants that could utilize natural gas. Several town gas projects have also been successful. In Anhui, the recent average wholesale price is 0.345 CNY/kWh; however, mines such as the Liuzhuang mine may pay as high as 0.85 CNY/kWh peak-period power rates, and during more typical conditions, 0.57 CNY/kWh. These rates make mine site power projects look attractive in Anhui. Regarding natural gas prices, the citygate price paid in Anhui from the West-to-East Pipeline is similar to retail prices paid by automotive compressed natural gas (CNG) users in Chongqing and similar long-distance pipeline customers in Guizhou.

Chongqing has one of the oldest and best-developed natural gas distribution infrastructures in China due to its proximity to the Sichuan gas fields. Its total natural gas consumption grew at about 8.5 percent per year to an estimated 5.8 billion cubic meters from 2005-2011, putting it in the top four provincial-level consumers on a per capita basis. Supply of natural gas has been the most important constraint to more rapid growth in consumption. The municipal government estimates that Chongqing could absorb 15 billion cubic meters by 2015, two and one half times 2011 usage, as urbanization continues and industry expands.

From a supply-demand point of view, there is no doubt that purified CMM is welcome in Chongqing. Furthermore, the Municipality's coal mining companies, led by the Songzao Coal and Electricity Company under Chongqing Energy Investment Group, have recovered significant volumes of methane for many years for mine area civil use. The Chongqing Gas Group, for a number of years, has purchased about 20 million cubic meters per year of pipeline quality CMM from the Chongqing Energy Investment Group's Zhongliangshan Coal Mine located near the municipal center (UNFCCC, 2011).

Despite the striking increase in the volume of Henan's natural gas consumption to 7.4 billion cubic meters in 2012, natural gas accounted for no more than three to four percent of primary energy supply. As is the case throughout China, supply is constraining consumption, and will likely continue to do so for the rest of the decade, barring breakthroughs in supply of shale gas, evident as of early 2014. Industrial and residential consumption of gas rose substantially between 2009 and 2012. These trends will continue for the foreseeable future, given the unmet potential for fuel switching in industry and the desire of urban residents for clean fuel. Natural gas supply will fall short of demand in Henan without discovery of a major new conventional gas deposit or a breakthrough in shale gas development efforts. From a supply and demand perspective, the province should be able to absorb all pipeline quality CMM that becomes available.

Currently natural gas in Guizhou is limited to LNG trucked in and used for a small number of residential and automotive customers. Guizhou's pipeline network is expected to expand with the China National Petroleum and Gas Corporation (also known as CNPC or PetroChina) pipeline from Burma completing in 2013. The trunk pipeline will enter Guizhou from Yunnan Province to the west and run a reported 300 km eastward through Anshun Municipality, Guiyang, Duyun Municipality, Dushan and Libo Counties and onward to Guangxi Province. The Guizhou Gas Group has developed preliminary plans for a network of branch pipelines from the trunkline, including a line that would run north from Guiyang towards the city of Zunyi. These developments increase the potential viability of different kinds of CMM projects, as currently no CMM is known to have been used outside of the immediate mining areas. Guizhou has two CMM projects, a power generation project and a town gas project.

Guizhou coal fired power wholesale prices are slightly lower than other provinces. Guizhou's electric power is expected to remain strongly cost competitive in view of the availability in Guizhou of inexpensive local coal and water resources. Guizhou is a largely untapped gas market, thus gas prices are based mostly on pipeline and LNG prices. Cities served by long-distance pipelines are paying a high 2.5-3.0 CNY/cubic meter.

In Inner Mongolia, low wellhead, gas transmission, and retail sales prices prevailing in the region surrounding the Changqing gas field present economic obstacles to the sale of purified CMM to either CNPC for pipeline injection or for sale to local distribution companies. Given the relative abundance of available conventional gas, it is unlikely that a pipeline would be extended dozens of kilometers to absorb small volumes from a producer such as the Tai Xi coal mines in Alashan on the west side of the Yellow River.

LNG presents a much more feasible prospect for CMM producers. The LNG plant offers mines such as Tai Xi the flexibility to pursue a number of different marketing outlets simultaneously, including local civil use (a possibility in a location such as Alashan that did not as of 2012 have a local distribution system) and higher return end-uses such as automotive use and sales to richer provinces with higher prevailing gas prices.

1.5 CMM Projects in China

Throughout China there are a number of successful CMM projects. China has 67 operating projects within 14 provinces (GMI, 2014). In China, the main types of CMM use projects are town gas, electricity generation, industrial boiler fuel feed, vehicle fuel, and thermal applications (e.g., office space heating). Some Chinese CMM projects involve multiple end uses. As of 2012, China's CMM use projects utilized 3.5 billion m^3 of methane (Huang, 2013a). CMM-to-power projects generated a total of more than 1,500 MW of power by the end of 2011 (Huang, 2013b). As of September of 2014, 92 CMM projects have been prepared for the CDM and approved by the central government; of those, 58 projects have been registered with the United Nations Framework Convention on Climate Change (UNFCCC). CERs have been issued from 30 of these projects (Huang, 2014). The Huainan and Huaibei mining groups have had success with numerous projects in Anhui province. Anhui has three registered CDM projects: Huaibei Haizi and Luling Coal Mine Methane Utilization Project, Anhui Huaibei Taoyuan Coal Mine Methane Utilization Project, and Anhui Huaibei Qinan Coal Mine Methane Utilization Project.

Chongqing has four operating CMM projects (GMI, 2014). Three projects are registered CDM projects: Zhongliangshan Coal Mine Methane Project, Nantong Coal Mine Methane, and Tianfu Coal Mine Methane Project. The Chongqing Datong Coal Mine Ventilation Air Methane (VAM) Destruction and Utilization Project is capable to reduce greenhouse gas emissions by up to 200,000 tonnes of CO_2e per year (CMOP, 2010). Chongqing is also home to the world's largest CMM purification and liquefaction project underway as of 2015, a project facilitated by a USEPA-funded feasibility study.

Henan has nine operating CMM projects and the Hebi area has two. Henan is home to one registered CDM project, Jiaozuo Coal Mine Methane (CMM) Power Generation Project of Jiaozuo Coal Industrial Group Co. Ltd., Jiaozuo City, Henan Province. Guizhou has two operating CMM projects and several in development. Two CMM projects from Guizhou are at the validation phase of the CDM process.

There are multiple benefits to developing CMM projects in China. CMM projects reduce greenhouse gas emissions, improve mine safety, create jobs, improve local and regional air quality, and provide energy independence-of particular importance as China's energy needs are expected to double from 2005 to 2030 (IEA, 2009.1). China has the world's highest CMM emissions, with nearly 13 percent of the world's total in 2010 (USEPA, 2012). With a booming coal market and government policies to encourage natural gas and CMM development, CMM projects are expected to continue to be favored.

This synthesis of energy market analyses derived from several comprehensive studies of CMM recovery and utilization opportunites located in Anhui, Chongqing, Henan, Inner Mongolia, and Guizhou laid the foundation for this document. Coal dominates China's energy market, and despite years of double digit growth in the gas industry, current coal consumption is expected to grow even more. Increases in electricity consumption have surpassed overall economic growth, and because China is a zero importer/exporter of electricity, its growth has come entirely from domestic generation, which overwhelmingly is fueled by coal. Though China's government has implemented a number of policies and mechanisms to encourage conventional and unconventional natural gas, including CMM development with some success, there are a number of barriers to a widespread and flourishing CMM market. This report pinpoints the differences found amoung the provincial energy markets. Knowledge of these differences will provide project developers with information that can be used advantageously for determining the best approach for successful projects that produce clean energy while reducing methane emissions. This document supports USEPA's efforts to promote international collaboration to advance methane capture and use projects that bring more gas to market, and reduce CMM emissions.

2. Introduction

This document reports the energy market analysis of several comprehensive coal mine methane (CMM) recovery and utilization feasibility studies that were conducted as a part of a larger initiative funded by the United States Environmental Protection Agency (USEPA). This initiative supports USEPA's efforts under the Global Methane Initiative (GMI), formerly the Methane to Markets Partnership (M2M). On 1 October 2010, thirty-eight governments, the European Commission, the Asian Development Bank, and the Inter-American Development Bank launched GMI to urge stronger international action to fight climate change while developing clean energy and stronger economies. GMI builds on the existing structure and success of M2M to reduce emissions of methane, while enhancing and expanding these efforts and encouraging new resource commitments from country partners. GMI is fostering international collaboration to advance methane capture and use projects that bring more gas to market.

2.1 Background-source of data and analysis

Much of the data in this report comes from China's National Development and Reform Commission (NDRC), National Bureau of Statistics of China (NBSC), and the China Energy Statistics Yearbook (CESY); as well as various news stories and analytical reports such as those completed by the International Energy Agency (IEA).

2.1.1 Background info on USEPA feasibility and pre-feasibility studies in China

In support of GMI, USEPA's Coalbed Methane Outreach Program (CMOP) has launched five full-scale feasibility studies of coal mine methane recovery and utilization projects at Chinese coal mines. The studies assess the technical and economic viability of implementing methane recovery and utilization projects, with detailed findings and project implementation recommendations compiled in comprehensive final reports. The information in this study comes from the following feasibility studies: Feasibility Study of CMM Utilization for Songzao Coal and Electricity Company Coal Mines (May 2009), Feasibility Study for Coal Mine Methane Drainage and Utilization at Hebi No. 6 Coal Mine, Henan Province, China (2010), Feasibility Study for CMM Drainage and Utilization at Liuzhuang Coal Mine, Huainan Coal Field (February 2010), Feasibility Study of CMM Utilization for Guizhou Nengfa Power Fuel Development Co., Ltd. Linhua Mine Located in Guizhou Province (December 2010), and Feasibility Study for CMM Drainage and Utilization: Inner Mongolia Tai Xi Group Mines (December 2011). EPA has also completed pre-feasibility studies in China which include market information used in this report. All The studies can be found at http://epa.gov/cmop/international/china.html.

2.2 China's energy use

Coal dominates China's energy market with an estimated 69 percent contribution to energy needs in 2011 (EIA, 2014). EIA envisages coal's share of the total energy mix to fall to 63 percent by 2020 and 55 percent by 2040 due to China's desire to reduce heavy air pollution which has affected certain areas of the country and anticipated increased efficiencies and China's goal to increase its environmental sustainability; however, absolute coal consumption is expected to double over this period, reflecting the large growth in total energy consumption due to economic growth (EIA, 2014). China plans to reduce carbon emissions per unit of gross domestic product (GDP) by at least 40 percent from 2005 levels by 2020. China has also announced plans to reduce its energy intensity levels (energy consumed per unit of

GDP) by 16 percent between 2010 and 2015 and increase non-fossil fuel energy consumption to 15 percent of the energy mix by 2020 (EIA, 2014).

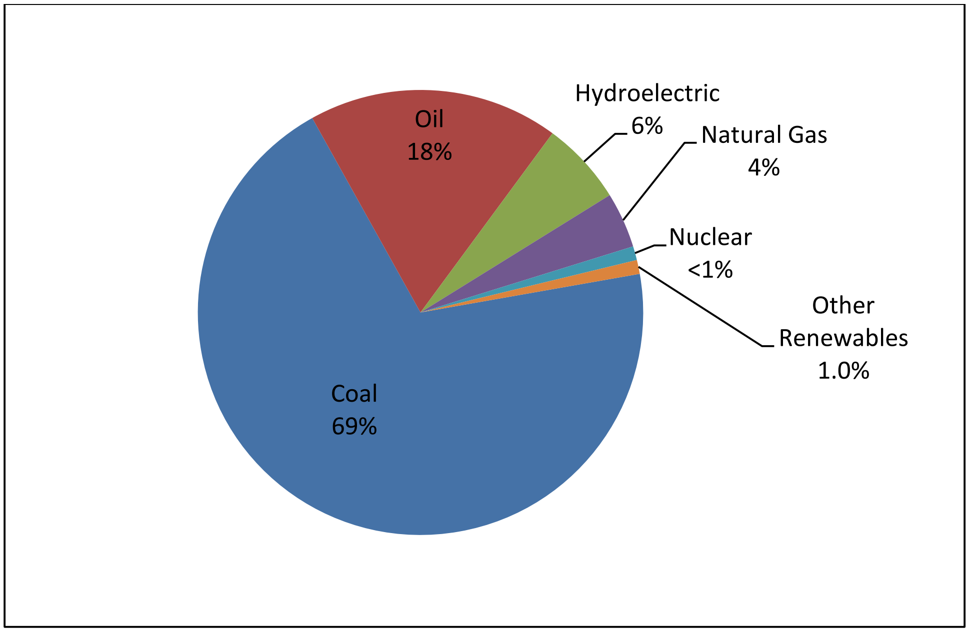

FIGURE 9: CHINA'S ENERGY MIX
Source: EIA (2014)

Figure 9 shows estimates of various components' contributions to China's energy mix as estimated by the U.S. Department of Energy's Energy Information Administration (EIA).

2.3 Summary of China's CMM Activity

Ongoing CMM projects are found in 16 countries. China, Australia, Czech Republic, Germany, Poland, United Kingdom, and the United States in particular host numerous projects at active mines, while Germany, Ukraine, United Kingdom, and the United States host many projects at abandoned mines. China leads the world in reducing CMM emissions by 31.8 million tonnes carbon dioxide equivalent ($MtCO_2e$) with boiler fuel, combined heat and power, industrial use, power generation, town gas, ventilation air methane (VAM) destruction, and vehicle fuel projects. China has 92 CMM projects prepared as CDM Projects and were approved by the central government (Huang, 2014). Australia and the United States follow with reductions of 9.1 and 7.0 $MtCO_2e$, respectively (GMI, 2010; GMI, 2012).

2.4 How to use this document if undertaking CMM projects in China

This document is intended to be used by project developers and carbon finance groups seeking CMM and VAM emissions reduction opportunities in China. This document provides information and analysis that can be used to inform decision making processes as a project's scope, location and pro forma economics are being considered. Information provided herein can aid the developer in determining the type of emission reduction project that is best suited for the region based on access to infrastructure that will deliver the product to market, potential customers, and expected range in market prices. The user should conduct due diligence before undertaking a CMM or VAM emission reduction project in China as the provincial level economy changes rapidly.

The mines that were subjects of the aforementioned feasibility studies, as well as several completed or underway CMM projects, are referred to in many sections of this report as examples of what can be done if market research is solid and mine management sees the benefit to commercial project implementation.

3. Coal Market

3.1 National Coal Market Overview

3.1.1 Growth in China's Coal Production

The large number of suppliers, and in particular the significant role played by small, lightly regulated mines owned by local governments or private interests, cause official coal production statistics to be less accurate than those of other forms of energy such as electric power and natural gas. While the overall patterns described below are based on recently reported official statistics or estimates and are reasonably reliable, some of the specific numbers may diverge from the underlying reality, and some inconsistencies can be seen when comparing statistics from different sources. In particular, certain statistics (e.g., provincial reports on annual output based on "mines of scale") appear to leave out a substantial portion of small mine production. Even national total output statistics contained in official documents, which try to account for the entirety, are on occasion revised after release.

3.1.2 Supply/Demand

Coal has consistently accounted for 68-70 percent of China's primary energy since 2000 (**Table 1**), (assumed thermal value 5000 kcal/kg), with consumption rising by an average 8.4 percent per year to a level of 3.77 billion tonnes in 2012, close to 50 percent of the world's total. Despite official calls to gradually reduce the weight of coal in the energy mix, the percentage actually increased slightly between 2005 and 2009 as heavy industry surged.

TABLE 1: ESTIMATED COAL CONSUMPTION IN CHINA, 2000-2012
(MILLION TONNES, 5000 KCAL/KG THERMAL VALUE AVERAGE)

Million tonnes	1,320	2,167	2,390	2,580	2,810	2,958	3,220	3,390	3,765
Percentage of total primary energy (%)	68.0	68.9	69.4	69.5	70.3	70.4	68.0	68.4	66.6

Source: CESY (2013), p. 55; NDRC (2008.1); NBSC (2012); EIA (2014)

Table 2 below shows the prevalence of coal in the mix of China's primary energy sources. Domestic coal production and transport capacity has strained to keep pace with demand in recent years, with output rising by only 3.6 percent from 2011 to 2012.

TABLE 2: RAW COAL SUPPLY IN CHINA

Year						
2000	1,299	NA	55.1	NA	2.2	NA
2001	1,382	6.4	90.1	33.8	2.7	18.5
2002	1,455	5.3	83.9	(7.4)	11.3	76.1
2003	1,722	18.4	94.0	10.7	11.1	(1.8)
2004	1,992	15.7	86.7	(8.4)	18.6	40.3
2005	2,204	9.9	71.7	(20.9)	26.2	29.0
2006	2,373	7.7	63.3	(13.3)	38.1	31.2
2007	2,526	6.4	53.2	(19.0)	51.0	25.3
2008	2,622	3.8	45.3	(14.8)	40.4	(20.8)
2009	2,980	13.6	22.4	(50.5)	125.8	210
2010	3,240	8.9	19.0	(15.2)	164.8	31
2011	3,520	8.7	14.7	(22.6)	182.4	10.7
2012	3,645	3.6	9.3	(36.7)	288.4	58.1

Source: CESY (2008); CESY (2010); China Daily (January 27, 2011); China Coal Society (January 17, 2012); China Newsweek (2012); NBSC (2012); NBSC (2008); China Customs (2009.1); CESY (2013)

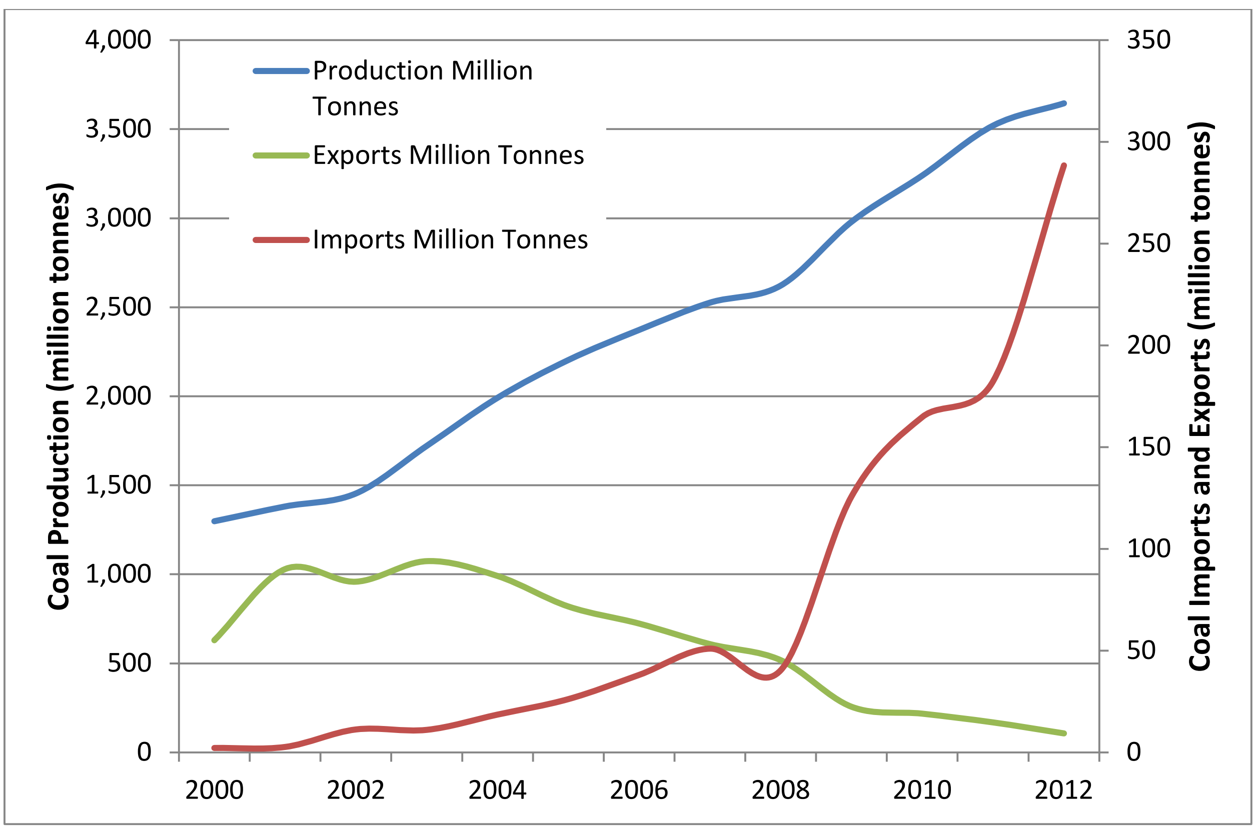

FIGURE 10: CHINA'S RAW COAL SUPPLY
Source: CESY (2013) p. 11, 36

As a result, China has been transformed from a net coal exporter into the world's largest importer, with net imports reaching 288.4 million tonnes, or 4.8 percent of total consumption on a physical quantity basis, and over 5 percent on a heat value basis in 2012 (**Table 2**, **Figure 10**). Imports are consumed primarily in the southern and eastern coastal cities, the primary victims of coal transportation bottlenecks, and in steel mills.

3.1.3 Structure of Demand for Coal

Thermal power generation has been the most important driver for coal industry expansion, accounting for approximately half of total consumption in recent years, followed by steel and cement, which have accounted for about 25 percent of the total (**Table 3** below). Each of these three core end-use industries grew by an average 11-12 percent per year from 2005-2012, with slower growth in the most acute years of the global financial crisis from 2008-2009, and faster growth both before and after.

TABLE 3: COAL END USE

Total (million tonnes)	2,319	2,551	2,728	2,810	2,958	3,122	3,430	3,526
Industry	92.9%	93.5%	93.9%	94.5%	94.6%	94.8%	95.1%	95.2%
--Electricity and Heat	*46.4%*	*48.0%*	*49.6%*	*49.1%*	*49.4%*	*48.9%*	*50.1%*	*47.7%*
--Coking, nuclear fuel, Petroleum processing	*8.5%*	*9.0%*	*9.2%*	*9.4%*	*9.2%*	*9.5%*	*9.9%*	*10.3%*
-- Iron and Steel	*9.2%*	*8.8%*	*8.4%*	*8.6%*	*9.0%*	*9.0%*	*8.7%*	*8.6%*
-- Non-metallic Minerals	*8.6%*	*8.1%*	*7.5%*	*8.2%*	*8.0%*	*7.5%*	*7.3%*	*7.0%*
-- Coal Mining/Washing	*6.3%*	*6.1%*	*6.5%*	*6.5%*	*6.8%*	*7.4%*	*7.2%*	*7.4%*
-- Chemicals	*5.6%*	*5.4%*	*5.2%*	*5.4%*	*5.1%*	*4.7%*	*4.7%*	*5.0%*
Residential	4.3%	3.9%	3.6%	3.3%	3.1%	2.9%	2.7%	2.6%
Other	2.7%	2.6%	2.5%	2.2%	2.3%	2.3%	2.2%	2.2%

Source: CESY (2013) p. 70 - 71

In addition to the coal used directly for the iron and steel industry, almost the entire end product of the coking category is also used for iron-making. The use of coal as a household fuel has dropped in both percentage and absolute terms, particularly in urban areas. As a result, Industry's overall share of coal consumption has risen to 95.2 percent (CESY 2013, pp. 70 - 71).

3.1.4 Demand for Coal through 2015

Coal demand growth since 2000, as noted above, has been fueled by the rapid growth in output of electric power and heavy industrial commodities such as steel and cement. Demand for these products, has been driven by double digit economic growth financed by an explosion in exports and centered on investment in infrastructure, factories (including export processing factories themselves), and urban real estate (World Bank, 2012).

Investment rose to about 50 percent of GDP over this period, an extremely high number, even for a transforming economy such as China's. Under these conditions, growth of coal consuming sectors has averaged 6.1-11.1 percent from 2007-2012 as shown in **Table 4**.

TABLE 4: ECONOMIC GROWTH AND COAL CONSUMING SECTOR GROWTH

	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**Average 2007-2012**
GDP Growth	13.0%	9.0%	9.7%	10.3%	9.2%	7.7%	9.8%
Thermal Electricity Output Growth	14.9%	2.5%	6.9%	11.7%	14.8%	5.8%	9.4%
Steel Output Growth	15.9%	2.3%	14.2%	11.4%	7.3%	NA	10.2%
Cement Output Growth	9.7%	4.6%	15.5%	14.8%	10.8%	NA	11.1%
Coal Consumption Growth	6.9%	3.1%	5.2%	8.8%	9.6%	2.8%	6.1%

Source: CESY (2013)

The exception to this pattern occurred in the second half of 2008 to the first half of 2009, when economic growth slowed to as low as six percent under the combined impact of the global financial crisis and government-mandated tightening of the real estate market (World Bank, 2012). Production of steel, cement, and electricity declined in absolute terms during forth quarter 2008 and first quarter 2009.

The investment-centered economy in China recovered quickly, however, as the global economy stabilized and the Chinese government implemented a 4 trillion CNY (625 billion USD) infrastructure-centered stimulus program. Previous patterns of growth resumed from the second half of 2009 through the end of 2011.

Since the beginning of 2012, the Chinese economy has slowed once again under the combined impact of a foreign shock from Europe, Chinese government efforts to control inflationary real estate transactions, and the wrap-up of 2008-2009 stimulus spending. As economic growth dropped to a reported 7.6 percent in the second quarter and export growth slowed almost to a halt, output of the coal-consuming thermal electric power, steel, and cement industries decreased to 2.6, 1.8, and 5 percent respectively by mid-year (NBSC, 2008-2012; NBSC, 2012.1).

The World Bank projects overall growth at about 8.5 percent from 2011-2015, but with gradual transition from investment-heavy, industry-led growth (down to 40 percent of total GDP by 2015) towards a more significant role for consumption (up to about 55 percent by 2015) (World Bank, 2012).

The Plan's target growth rate is seven percent, with the share of services increasing by four percent. In the government's words, "Increasing consumer demand will be the strategic centerpiece of economic stimulus and growth. Investment and consumption must be mutually reinforcing" (Xinhuanet, 2011). The entire focus of the Plan is on quality rather than quantity of growth.

Continuing urbanization (predicted to rise by five percentage points to about 55 percent by 2015), demand for products such as automobiles, as well as momentum from the past will ensure continued growth in the coal-consuming power heavy industrial sectors. But they are unlikely to outpace the economy as a whole by 30 percent or more as in previous years.

A more reasonable projection, once the economy has recovered from the cyclical downturn of 2012, is for demand for thermal electric power and the other major products using coal as an input to grow at roughly the same 7-8.5 percent rate as the economy as a whole. This was the prediction of the China Electricity Council for its own "Rolling Five-Year Plan Estimate" of 2012, and it is what occurred in practice during the early phase of the rebound from the 2008-2009 slump (China Electricity Council, 2012). However, according to China's Coal Industry Association, production fell in 2014 by 2.5 percent below the 3.7 billion tonnes produced in 2013, even while China's coal production capacity was being increased by one billion tonnes (Financial Times, 2015).

In addition to more moderate growth rates for the products that use coal, greater energy efficiency in the manufacture of these products, combined with some fuel switching to natural gas, will also act to dampen demand for coal. The major impact of these factors on coal consumption during the 2005-2010 period can be seen in **Table 5** below.

TABLE 5: IMPROVING ENERGY EFFICIENCY OF COAL CONSUMERS

Coal Consumers			
Thermal Electric Power	8.1%	9.9%	0.81
Steel	7.0%	12.9%	0.54
Cement	4.3%	11.2%	0.39

Not all of the potential has been captured. In the thermal power sector, the current reported average coal consumption rate is 330 grams of standard 7000 /kg) coal per kWh (NEA, 2012). But the 600 MW supercritical coal boilers and 1000 MW ultra-super-critical boilers that have accounted for virtually all new coal fired power capacity in China since 2005 have reported coal consumption rates of about 310 and 290 grams per kWh.

As these units continue to replace less efficient smaller scale (≦300MW) units during the Twelfth Five-year Plan, it is reasonable to project at least an additional 5 percent decrease in coal consumption per unit of new power production. Almost all new coal burning capacity will consist either of 600 MW supercritical units or 1000 MW ultra-super-critical units with estimated coal consumption of 310 grams of "standard" (7000 kcal/kg) coal per kWh and 290 grams per kWh respectively, compared to reported 330 kWh national average at year-end 2011 (NEA, 2012).

As these new high efficiency units come online, the significant existing stock of lower efficiency 10-300 MW coal-fired units is being gradually shut down, a process that will be well on the way to completion by the end of the Twelfth Five-year Plan in 2015. Under such circumstances, it is plausible to project at least a further 4-5 percent drop in coal-fired power plant unit fuel consumption.

If coal-fired power generation increases by 7.5 percent per year and unit coal consumption decreases by 5 percent over the entire 2011-2015 period (i.e., slightly less than 1 percent per year), coal consumption in the power industry would increase by about 6.4 percent. Given the potential for further efficiency improvements in the other major sectors, this is probably a reasonable projection for overall increase in coal demand during the Twelfth Five-year Plan.

3.1.5 Coal Production

3.1.5.1 Coal type

Output of coal by classification in 2010 was approximately as follows (**Figure 11**):

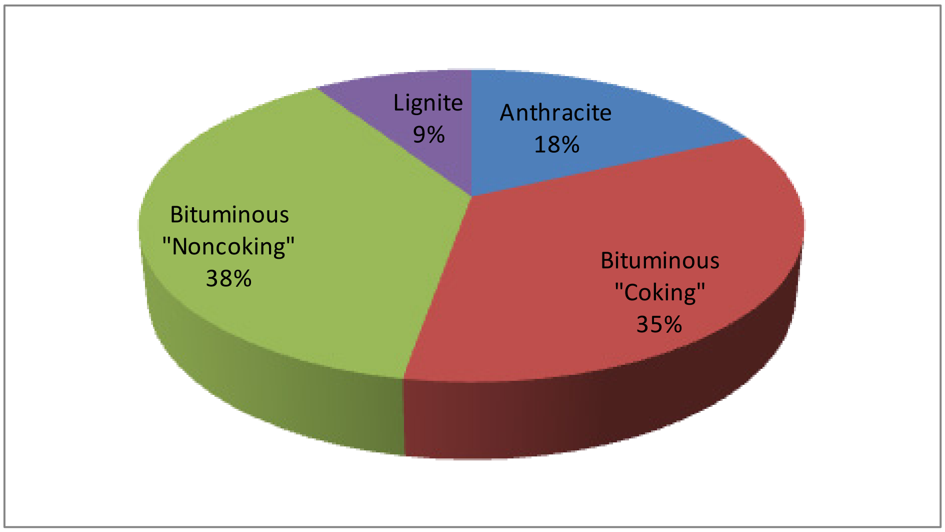

FIGURE 11: OUTPUT OF COAL BY CLASSIFICATION, 2010
Source: Gaoping Coal Beneficiation Association (2010); Industrial Futures (2011)

The Chinese definition of coking coal, which follows former Soviet standards, covers a somewhat broader range of coals than the western definition does; only about 25 percent of coking coal is actually used to make coke, the remainder burned for heat in power plants, cement factories, etc. A portion of China's anthracite coal is also used for power generation, with much of the rest used as raw material for ammonia fertilizer and other chemical production. China's bituminous non-coking coal is used primarily for power generation with some used in industry and for heating. Lignite is also used in power generation.

3.1.5.2 Coal Production Company Ownership

Role of small-scale mines

China's coal mine ownership has been split for many years between: (1) central and provincial government companies operating large scale, fully mechanized mines (mainly underground) (2) sub-provincial (county) government companies operating smaller mines with an average capacity of several hundred thousand tonnes; (3) 10,000 or more townships, villages and private companies operating semi-mechanized mines, many with capacities less than 100,000 tonnes.

The short mobilization and construction lead times of the township and village mines gave them a particular advantage in the early years of the coal boom starting from 2000, as coal prices were partially freed and the economy took off. As of 2007, the central and provincial level companies accounted for 49 percent of national output, with the township and village mines at 38 percent, and the sub-provincial mines accounting for the rest (China Coal Society, 2008).

The central government planning and regulatory authorities have long desired to rein in the township and village mines with their spotty safety records and uneven coal quality control, their inefficient utilization of coal resources, and their impingement on the operations of larger, more productive mines. The government has vowed to either shut down mines of less than 300,000 ton per year capacity or to force their merger with larger, more mechanized operations.

These efforts have born some fruit in recent years. The NDRC reports that the country's 661 mines of over 1.2 million tonnes capacity accounted for 58 percent of national output in 2010, and that 47 mining companies with scale of over 10 million tonnes per year (a category that largely overlaps with that of mines over 1.2 million tonnes) accounted for 63 percent (NDRC, 2012.1). More than 1,100 small coal mines mines were closed in 2014 and the central government intends to continue closures, targeting 2,000 mines in 2015 and stating that additional mines must be closed in 2016 to meet its goal of having no more than 10,000 small mines operating. (China Daily, 2014.2)

The government's efforts appear to have achieved the most success in the older mining areas of Henan and Shanxi (see Henan Coal Section below) by eliminating mines owned by sub-provincial interests in newer developing areas such as Inner Mongolia and northern Shaanxi, but their average size is most likely higher than in the older areas (Qinhuangdao Coal Net, 2012).

There remain significant incentives for local governments to maintain mines under their jurisdiction. But trends in coal supply/demand and pricing may end up somewhat reinforcing the central government's position. Large coal consumers are more likely to prefer working with the larger, more established mines in a soft market such as that of mid-2012, and these mines are in a better financial position to weather a downturn.

Ownership and operation of the modernized mining sector

There has been a clear drive towards consolidation, not just of the small inefficient mines, but also among the larger mining companies themselves. With government backing, companies that previously operated only in one locality within a province are now operating mines dozens of miles apart, and some even operating transprovincially.

The latter include the Shenhua Mining Company, one of two coal mining companies owned by the Central government, which produced 318.1 million tonnes in 2013 from five mining complexes located in Shaanxi, Shanxi, and Inner Mongolia (Shenhua China, 2014), and the Datong Coal Group owned by the Shanxi Provincial government, which was number two in the country at 194 million tonnes in 2011. Shenhua's assets include several underground mines producing over 20 million tonnes from one or two longwall panels. In addition to these two, three other companies exceeded 100 million tonnes output (Shenhua Coal Company website; Datong Coal Company website; NDRC, 2012.1).

In some cases from their own initiative to secure coal supply and in others because they have been pressured to do so by the government, the major government power generators have pursued coal mine investments and acquisitions. Some move towards vertical integration has also worked in the other direction as companies such as Shenhua build power generation facilities, and even railroads and ports.

3.1.5.3 Geographic Distribution

China's coal reserves and production are disproportionately concentrated in the northeastern and central part of the country as shown below in **Figure 12**. The two neighboring provinces of Inner Mongolia and Shanxi accounted for 979 and 872 million tonnes of production, respectively in 2011, almost 53 percent of the national total. Growth in Shanxi, China's traditional coal powerhouse, has been gradual compared to Inner Mongolia, where reported output increased by a startling 329 percent from 2006-2011. The bulk of this new production came from the development of rich, previously unexploited properties made possible by the completion/expansion of a series of railroads to move the coal.

Shaanxi Province in the northwest accounted for an additional 400 million tonnes and 11 percent of total production. The Shenfu coalfield, which spreads across the border area of Shaanxi and Inner Mongolia, has provided the bulk of newly commissioned capacity in both provinces. These three provinces, together with Gansu and Ningxia, and to some extent Xinjiang, are going to account for the bulk of new production in the foreseeable future. The NDRC has called for 87 percent of the 740 million tonne capacity expansion that it proposes for the country during the Twelfth Five-year Plan to take place in these provinces (NDRC, 2012.1).

The three northeastern (Manchurian) provinces provided about 5.5 percent, and the four provinces of Hebei, Henan, Anhui, and Shandong located south and east of Beijing and north of the Yangtze River accounted for approximately 11.5 percent. The deposits in these areas have a long exploitation history; their costs are rising as mines are forced deeper, and they are unlikely to grow at a rapid rate in the medium-term future.

By contrast, the major Yangtze Delta and Pearl River load center provinces of Jiangsu, Shanghai, Zhejiang, Jiangsu, Fujian, and Guangdong only produced less than 2 percent of the national total. These areas depend heavily on coal transported by rail from the north central provinces (particularly Shanxi, Shaanxi and Inner Mongolia) to northern coastal cities such as Qinhuangdao, Huanghua and Tianjin, and by ship from these cities to their ultimate destinations, supplemented in recent years by imports from abroad.

The seven inland provinces south of the Yangtze River (Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Guizhou, Yunnan) account for approximately 23 percent of the country's population, but only 12 percent of its coal production. Guizhou, at 156 million tonnes in 2011, per year, is the largest producer of this group. Although the quantity, coal quality, and mining conditions of deposits in these provinces (excepting Guizhou) are generally inferior to those in the north, they are nonetheless being developed to the maximum extent, with northern coal relegated to a supplementary role due to limited north south rail transport capability and high transport expense (CESY 2008, p.109). The central government hopes it can gradually change this during the Twelfth Five-year Plan and beyond with more rail investment, and shut down some of the higher cost, lower-quality producers.

Slightly less than two thirds of China's coal production was shipped by rail for either short or long distances in 2011, the bulk of which originated in Shanxi, Inner Mongolia and Shaanxi. Judging by past trends, somewhere between one half and two thirds of the production from these three provinces was transferred southward or eastward. The remainder was used onsite in power plants and chemical plants, or shipped moderate distances by truck.

Substantial, though not yet sufficient rail capacity has been developed to move the coal from the three major producing provinces to the northern coastal ports from which it is transported by boat to the major eastern and southern load centers. A reported 653 million tonnes, or 19 percent of total coal production, was shipped in this manner in 2011 (China Taiyuan Coal Transaction Center, 2012).

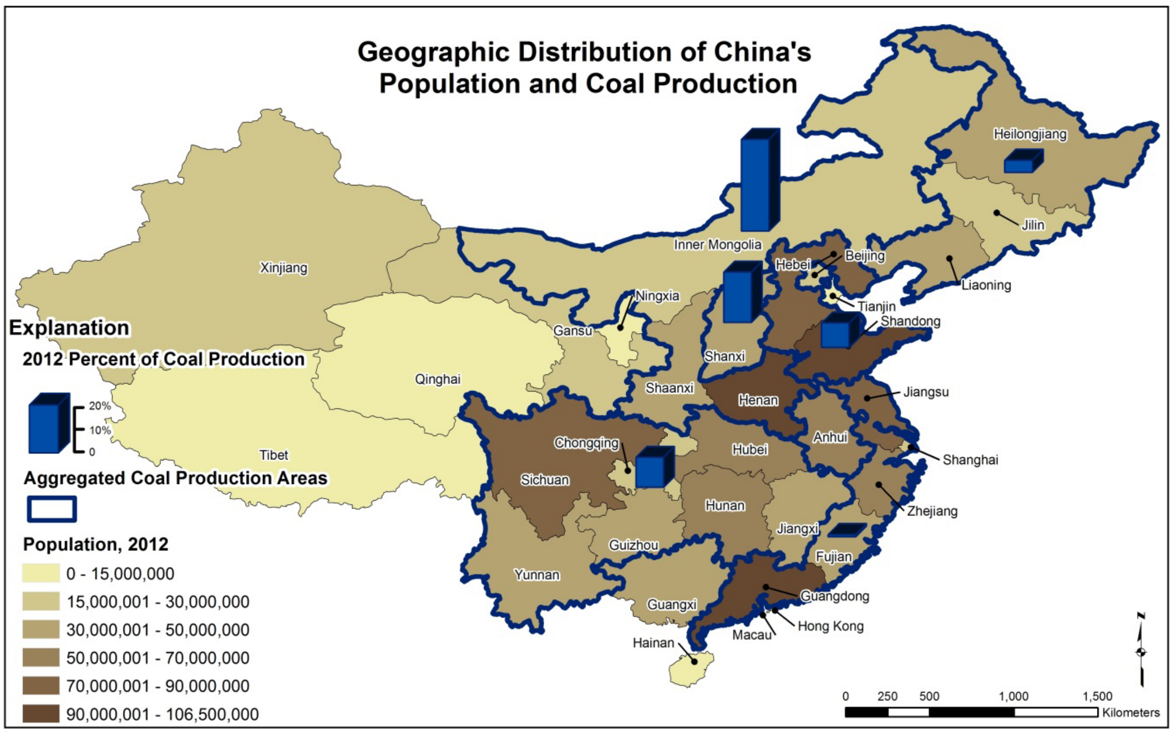

FIGURE 12: GEOGRAPHIC DISTRIBUTION OF CHINA'S COAL RESERVES AND PRODUCTION 2012
Source: CESY (2013)

3.1.6 Marketing and Pricing

As the central government released control of the large mines to provincial governments during the late 1990s and the turn of the 21st century, it also gradually relaxed control of marketing and pricing in order to ensure an adequate supply of the country's most important source of primary energy. This decision, together with a sustained upsurge in coal demand (which had actually dropped in the late 1990s) transformed coal mining companies from money losers to money earners by 2002, and was a key factor behind the coal production boom of recent years.

NDRC still maintains a certain degree of influence over coal pricing for power plants, chemical plants, and households through its oversight of rail transport of coal across provincial boundaries. Under a system set up in 2010, it fixes quotas for transprovincial coal shipment from each major coal company to customers in the above mentioned sectors under “long-term contracts” (in most cases, pricing fixed for one year), for which it guarantees priority shipment in the state-operated railroad system, an important consideration in a system with chronic rail capacity shortages.

While NDRC does not directly dictate the prices, all agreements negotiated between buyers and sellers for such contract coal are posted on an online-platform for its review. In practice, the NDRC places upper limits on these contract prices in accordance with its own views of what is fair to all parties under market conditions.

In 2012, 835 million tonnes of coal were subject to quota under this system – 24 percent of total 2011 production, perhaps 40-50 percent of both the production of the major modernized producers and of projected power plant coal consumption, and perhaps 25 percent of chemical fertilizer coal consumption (NDRC, 2011.2). The goal of the program (by no means fully achieved) is to provide a modicum of price protection to those sectors whose products are subject to strict government price controls in the interest of macroeconomic and social stability, and which are therefore unable to pass coal price increases through to their final customers.

The power plant and fertilizer plants are forced to look to the market for the considerable portion of their coal requirements not covered under the contract system unless, as is sometimes the case, they can also get access to coal from in-province producers for which prices are controlled in an ad-hoc manner by provincial governments. End users such as steel and cement factories who are free to pass their costs through to final end users are basically left to fend for themselves in the open market.

3.1.7 Recent Market Trends

As the heavy industrial economy boomed, coal producers enjoyed a seller’s market starting from the end of 2009 through the beginning of 2012 as market prices increased at double digit rates, leading to a two-tiered price structure for steaming coal consisting of:

- Contract coal for power plant users as defined in **Section 3.1.6** above, which by the beginning of 2012 had reached approximately 600-630 CNY per ton (USD 94-99) 5500 kcal/kg heat value, delivered by rail to Qinhuangdao Port on the Bohai Gulf about 150 miles from Beijing. The rail freight portion can be estimated at approximately 150 CNY (24 USD) per ton (China Securities Journal, 2012).
- Spot-market coal which peaked at 830 CNY (USD 130) per tonne, delivered to Qinhuangdao in November 2011 (China Taiyuan Coal Transaction Center, 2012).

The significant differential between the two prices created obvious incentives for contract coal sellers to withhold shipment and substitute lower-quality coal, which gave rise to a third price tier, consisting essentially of contract coal sold on the black market at a price roughly halfway between the contract and spot market price.

The slowdown in thermal electricity, steel, and cement sales in the second quarter of 2012 caused the free market Qinhangdao-delivered price to collapse to a level only 30-50 CNY per tonne higher than

contract coal according to reports, as coal stockpiles throughout the country soared. This has led to some speculation that the NDRC could abolish the contract price/transportation quota system, allowing all coal to be sold at market prices (China Securities Journal, 2012).
While the NDRC did in fact reduce the coal volume covered under the system by about 10 percent in 2012, even prior to the price collapse of the transport quotas, it would be uncharacteristic for it to make such a major change based on price movements in one quarter (NDRC, 2011.3). The sharp drop, however, creates more incentives for producers not accustomed to the slack market to agree to longer-term contracts with customers in order to smooth out volatility.

3.2 Provincial level

3.2.1 Anhui

Anhui Province is located in eastern China across the basins of the Yangtze River and the Huai River. Anhui is shown in **Figure 13** below.

FIGURE 13: MAP SHOWING ANHUI PROVINCE

Anhui Province experienced an average 6.7 and 8.5 percent per year growth in coal production and consumption, respectively, from 2005-2013 (**Table 6**). Neither consumption nor production showed the fluctuations seen in many other provinces in 2008 and 2009 as a result of the global economic crisis.

TABLE 6: ANHUI PROVINCE COAL PRODUCTION AND CONSUMPTION, 2005-2013 (MILLION TONNES)

Year	Production	Consumption (including loss in washing plants)
2005	84.88	83.4
2006	83.32	88.31
2007	92.66	97.84

2008	110.79	113.77
2009	123.98	126.7
2010	130.30	133.7
2011	140.80	143.0 (est.)
2012	150.49	147.0
2013	138.96	NA

Source: CESY 2010, pp. 35, 83; CESY 2011,p. 195; CESY 2013 p. 198; Anhui Statistics Bureau 2011; Anhui Statistics Bureau 2012; Anhui Statistics Bureau 2013; Anhui Statistics Bureau 2014

3.2.1.1 Demand in Anhui

After increasing at double digit rates for most of the 21st century, coal consumption in Anhui grew at an average rate of 4.2 percent during 2011-2012 (**Table 6**, **Table 7**). The slowdown in the industrial (non-utility) sector was particularly noteworthy, with consumption actually declining in 2010, and growing at 3.5 percent in 2011-2012, despite double digit growth in traditional consuming industries such as cement. Consumption in coke ovens also declined even as pig iron output increased. Only in the utility sector, which accounted for 54 percent of Anhui's coal usage in 2012 (**Figure 14**), was the 9.5 percent growth rate of 2010-2012 comparable to earlier years.

TABLE 7: ANHUI COAL CONSUMPTION BY SECTOR, 2009-2012 (MILLION TONNES)

Electricity	58.3	65.3	78.4
District Heating	3.4	3.4	3.6
Coking	10.9	11.8	11.5
Industry	44.3	42.9	46.0
Loss in washing plants	4.8	4.3	3.7
Residential	3.1	3.4	1.5
Other	1.8	2.65	2.3

Source: CESY 2013, p. 198; CESY 2011, p. 194; 2010, p. 166

A portion of the slowdown probably resulted from displacement of coal by newly arrived natural gas (CESY, 2011; CESY, 2013). Growing use of gas is also the reason why burning of coal as a residential fuel in Anhui dropped from about 3.8 million tonnes in 2010 to a reported 1.5 million in 2012. It is doubtful that increased efficiencies played a significant role in the decline in coal consumption relative to industrial output increase, especially in industries such as cement and steel. Even in the power sector, the growth rate of generation from coal-fired power plants exceeded that of coal consumption by more than a percentage point, as larger units gradually replaced smaller ones.

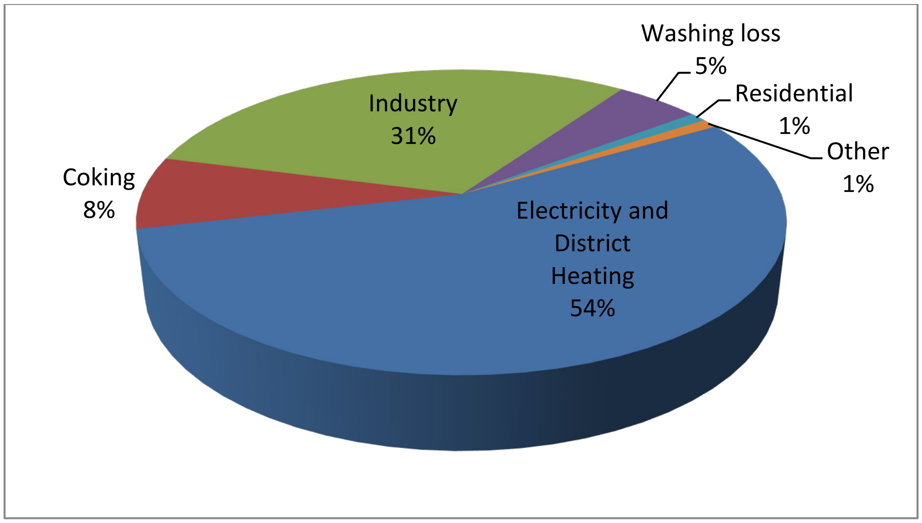

FIGURE 14: ANHUI COAL CONSUMPTION BY SECTOR, 2012
Source: CESY (2013)

Given the pace of power plant construction in Anhui and the demand for Anhui's power in the neighboring provinces of Jiangsu and Zhejiang, it can be reasonably assumed that Anhui coal-fired power generation will continue to increase at least in the 8-10 percent range for the medium-term. Power plant coal consumption has been lagging by a percentage point or two (see Anhui power section, below), increasing by perhaps 7-8 million tonnes per year.

3.2.1.2 Demand Outside of Anhui

As the coal production base closest to the major consumption centers in the East China coastal provinces, Anhui's coal production has been driven in the past by demand in these provinces as well as by growth in Anhui itself. In 2012, Anhui producers shipped 40 million tonnes outside the province, including the majority of its washed coal, matching the previous historical high (**Table 8**). Coking coal shipments from the Huaibei Mining Company to Bao Steel in Shanghai and other steel manufacturers accounts for a significant proportion. The State Council's Environmental Action Plan of 2013, which calls for coal consumption in the Delta provinces to begin to decrease by 2017 and requires that additional units at existing coal-fired power plants in these provinces displace at least an equal amount of consumption elsewhere, likely means an end to any significant growth in Anhui's coal shipments to the provinces (**Table 8**). These shipments are likely declining due to competitive difficulties faced by the Anhui coal companies, discussed below.

TABLE 8: COAL SALES INTO AND OUT OF ANHUI (MILLION TONNES)

Year	Into Anhui	Out of Anhui
2005	23.74	25.65
2007	33.64	29.51
2009	33.65	40.09
2010	38.51	38.57
2012	37.99	40.02

Source: CESY 2013, p, 198; CESY 2011, p. 194; CESY 2010, p.166

3.2.1.3 Production and Industry Structure

Virtually all of Anhui's coal output originates from four large mining groups: Huainan, Huaibei, Xinji and Wanbei. All except Xinji report to Anhui Province. Huainan produced 68.75 million tonnes of raw coal in 2013 from 13 mines, which was almost entirely bituminous steaming coal (Huainan Mining Group website). In 2012, Huaibei produced 37.11 million tonnes of raw coal from 22 mines. Approximately 11 million tonnes of metallurgical coal was produced, with the remainder being bituminous steam coal (China Coal Society, 2013). The Xinji Group in Huainan produced 19.9 million tonnes of bituminous steaming coal in 2013 from five mines, with a sixth under construction. The largest investor to the group is the central-government owned State Development Investment Corporation (Xinjin Group Annual Report, 2013). The Wanbei (North Anhui) Coal and Electricity Company in Suzhou City, produced 19.2 million tonnes in 2012 from 20 mines (China Coal Society, 2013).China's macroeconomic slowdown of 2012-2013 and the end of the 10-year coal boom market has had a profound effect on Anhui's coal industry. With growth in national coal consumption dropping to perhaps 2.5 percent per year nationally by 2013 and a severe glut in new low-cost capacity in Shaanxi and Inner Mongolia, market prices for 5500 kcal/kg power plant coal declined by one third from 800 CNY per tonne year-end 2011 to about 530 CNY per tonne in April 2014. The market price for 5000 kcal/kg coal sold by many Anhui producers had fallen to about 450 CNY per tonne (Xingnong Network, 2014).

Anhui mines, many of which are gassy and over 600 meters deep, are not cost-competitive with the Inner Mongolia/Shaanxi mines or with many of the foreign suppliers that are increasing their sales in Chinese markets. Mining costs at Huaibei, which are probably representative, were reported at about 511 CNY per tonne, with another 15 CNY per tonne for washing; with a washing loss of as much as 20 percent, this amounts to an effective cost of 650 CNY per tonne for cleaned coal (Huaibei Municipal Price Bureau, 2012).

Through 2011, Anhui mines had sold about half their steam coal to key end-users under annual contract prices at about 480 CNY per tonne (5000 kcal), more than making up for the loss on these sales with revenue from the remainder sold at market prices. By 2013, however, with market prices at or beneath the original contract prices, this cushion disappeared. Every major producer in the province lost money on coal operations, including Huaibei, which could still command higher prices for its metallurgical coal; cumulative losses amounted to a reported 3.5 billion CNY, or 20 CNY per tonne. Anhui's handful of smaller mines were put out of business, and production at some of the larger mines contracted due to market conditions (Market Weekly, 2014).

As **Table 6** shows, province-wide output in 2013 was lower than 2012 production by 11.5 million tonnes, or 7.7 percent. Production at Huainan appears to have declined by over 7 million tonnes or 10 percent (Huainan Mining Group Website; China Coal Supply Net, 2013). Undoubtedly the Anhui producers lost some market share with customers outside of the province to which they had become accustomed to selling at market prices, given the easy access of the Yangtze Delta provinces to imported coal or water shipments from the north. Judging by reports of pressures on the provincial government to induce Anhui enterprises to purchase locally, some in-province share was lost as well, in a year when provincial coal consumption increased order of magnitude of 4 percent (China Management Newspaper, 2013). Shipments from the north were already rising during the coal boom market as supply within the province tightened.

The large producers were able to cover their losses through non-coal operations, including real estate and, in many cases, coal-fired power plants; investments which became increasingly profitable as coal prices declined. Huainan Coal Group's 50 percent ownership shares in the Fengtai and Tianji Power plants dispatched directly to Zhejiang and Shanghai are the highest profile examples; Huainan Coal claims partial stakes in a total of 14 power plants with aggregate 13,000 MW capacity, sufficient to consume over 30 million tonnes of coal per year (Huainan Mining Group website). Under new market conditions, Anhui coal companies are attempting to expand their ownership shares in power plants to guarantee both market share and a piece of the power generation upside, showing a contrast to earlier years when power plants looked to invest in coal mines to guarantee coal supply and a piece of the mining upside. The decline in market price may also spur further investments in integrated coal-chemical enterprises, such as Wanbei's nitric acid plant.

As of 2014, it is not clear how the situation will resolve itself if market prices do not rebound significantly in the short term, particularly for mines that lack long-term contractual relationships with downstream users such as power plants. It is unlikely that new investments in coal projects will take place in Anhui under the conditions of early 2014, outside those in coking coal, which can still be sold at 1000 CNY per tonne as of early 2014, or steaming coal tied to specific power projects. Instead, the Anhui mining companies are focusing their new investments outside the province, led by Huainan Mining Group, which is developing four mines in Inner Mongolia with total design capacity of 40 million tonnes. The first two of these went into preliminary operation in late 2013. The profits from these lower cost mines in Inner Mongolia could help Huainan to bear the burden of continuing operations in Anhui if market prices do not improve. The coal market risk is a factor meriting some research for potential investors in specific CMM utilization projects in Anhui.

3.2.2 Chongqing

Chongqing, one of the five Chinese municipalities with provincial level economic status, is a major manufacturing and transportation center that is the economic hub of Southwest China and the Upper Yangtze River Valley, with a population of approximately 33 million. Approximately 2 million live in the central city and its immediate suburbs, with the remainder in 40 counties and satellite towns scattered through its 82,000 square kilometers. Fueled by a rapid pace of urbanization and some shift in overall investment towards the interior of China, its economic growth averaged 15 percent from 2005-2010, almost 50 percent higher than the national average. Chongqing Municipality is shown in **Figure 15**.

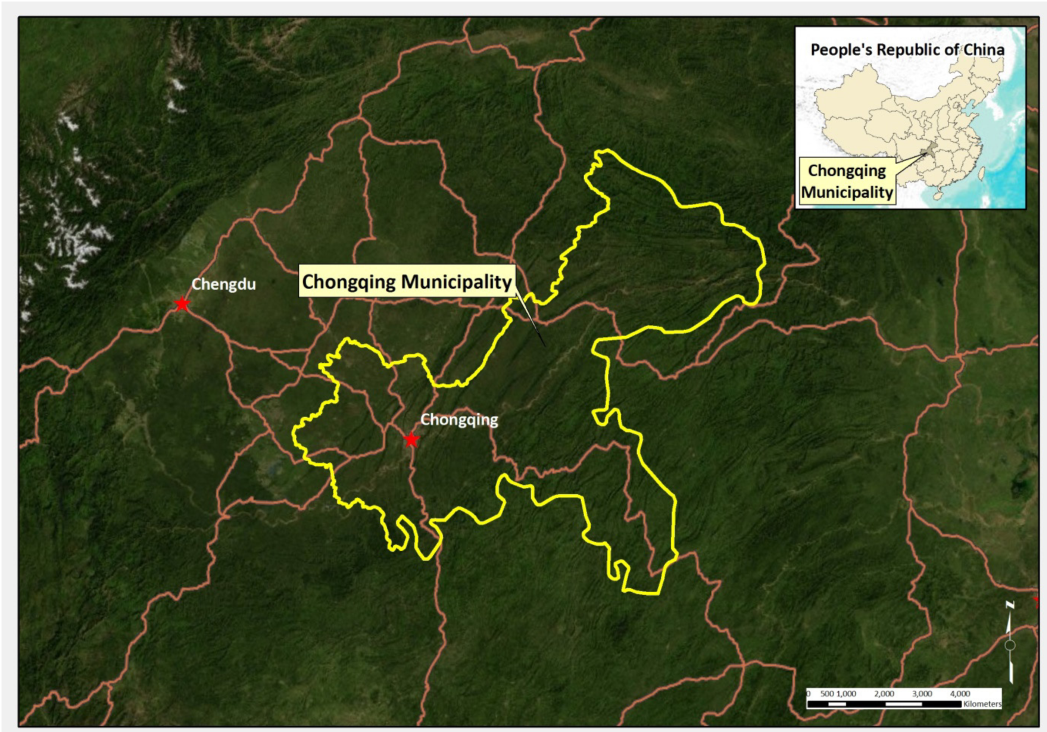

FIGURE 15: MAP SHOWING CHONGQING MUNICIPALITY

3.2.2.1 Supply and Demand

As Chongqing's growth accelerated, coal consumption grew from 2005 to 2012 to a level of approximately 67 million tonnes per year. Power and cement plants have been the largest drivers of coal consumption growth. A major steel mill also accounts for a significant share of consumption (**Table 9**).

TABLE 9: ESTIMATED COAL CONSUMPTION AND PRODUCTION IN CHONGQING (MILLION TONNES)

	2005	2006	2007	2008	2009	2010	2011	2012
Consumption (million tonnes)	33.3	37.4	40.8	52.7	57.81	60	NA	67.50
-Power Plants	10.8	12.0	17.6	NA	16.5	NA	NA	15.5
-Cement	3.4	NA	3.8	NA	4.0	NA	NA	NA
-Steel	13.7	NA	13.6	NA	28.5	NA	NA	NA
Production	36.2	39.9	42.9	46.7	42.9	45.5	44.6	35.7

Source: CESY 2008, p.92, 109; CESY 2010, p. 35, 206; CESY 2013, p. 258; Chongqing Bureau of Statistics 2011 and 2012; Chongqing Economic Commission 2007

Historically, the difficulties of transporting coal over the mountains from the north have forced Chongqing to rely primarily on its own coal production, despite the limited size, complex geology, high recovery costs, and mediocre quality of the municipality's high sulfur anthracite deposits. Starting from 2008, Chongqing became a progressively larger net coal importer as its own production plateaued (**Table 9**). Most incoming coal originated in Shaanxi Province to the north, with the remainder coming from Guizhou to the south.

Chongqing has been hit hard by the deceleration of economic growth throughout China in the first half of 2012. As the demand for power and heavy industrial commodities has moderated, its coal mines are no longer able to sell all their output, and losses have mounted. When the shorter term causes of economic deceleration subside, such as the Western European recession and cutback in domestic real estate transactions, growth in coal consumption is expected to resume.

However, demand is unlikely to rise in the medium-term at the same pace as 2005-2010. The most explosive phase of Chongqing's urbanization is over, and the city will likely grow close to the nationally projected average of 7-8.5 percent. If, as the central government projects, the focus of growth shifts somewhat in the direction of consumption, the major coal consuming industries will grow no faster than the overall rate of economic growth, and demand for coal will grow at a somewhat slower rate due to increased energy efficiencies.

If for some reason the demand resumes its explosive growth rate, supply could become a significant constraint. Given the limited volume and poor quality of Chongqing's reserves, it will be difficult to raise municipal production rapidly. Large-volume increase in shipments from northern coal surplus provinces such as Shaanxi will require major investments in north-south railroad lines (Qinghuangdao Coal Net, 2011).

The central government wishes for these investments to be made, and for high quality coal from the north to gradually displace coal mined in Chongqing. This will be a gradual process that takes place over a longer time perspective than covered by the Twelfth Five-year Plan (2011-2015) (NDRC, 2012.1).

3.2.2.2 Production and Marketing of Coal by the Chongqing Energy Investment Group

Of Chongqing's reported 44.6 million tonnes of coal production in 2011, approximately 13.5 million, or 30 percent, originated from the five mechanized, modernized mines of scale operated by the five mining companies under the Chongqing Energy Investment Company (CQEIG) owned by the municipal government: Songzao (5 million tonnes); Yongrong (3.5 million tonnes); Nantong (2.5 million tonnes); Tianfu (two million tonnes) and Zhongliangshan (750,000 tonnes). Their production increased at a rate of roughly three percent per year between 2008 and 2011. Because of the difficult mining conditions in Chongqing itself, some of the CQEIG companies are developing new production in neighboring Guizhou Province, and the CQEIG is considering investments in mines as far away as Xinjiang Province in the northwest (Chongqing Coal Safety Website; CQEIG 2012).

The remainder of Chongqing's coal production comes from smaller, less mechanized mines operated by lower levels of government in Chongqing or by private interests. Production in these mines has fluctuated, and they will bear the brunt of any cutback in demand or displacement by coal from the north. But at least as of early 2012, the municipality and central governments were still considering the construction of a large new power plant in one of the poorer satellite areas of the municipality fueled by local coal deposits in those areas.

CQEIG controls both the distribution and the pricing of 80-90 percent of the 13-14 million tonnes of coal produced by its five mining companies. This coal is allocated mainly to the municipality's large power plants and steel mills, but only fills a part (perhaps 50-75 percent) of their demand, the remainder of which is met by spot purchase from smaller local mines or from mines outside the province.

The Chongqing government strictly controls the price that CQEIG can charge power plants in the city. These prices have traditionally been set at one third to one half of market prices. By contrast, the CQEIG can charge market prices to industrial users within the city or to customers outside the province. This is an important reason why, despite the deficit of supply within the city, Chongqing coal producers have continued to sell as much as 20 percent of output to customers in other provinces. Virtually all the coal from non-CQEIG mines is sold at market prices, both in Chongqing and to other regions.

3.2.3 Hebi Area/Henan Province

Henan Province is located in Central China and Hebi, located in the north of the province, is situated in mountainous terrain at the edge of the Shanxi plateau. Henan Province and Hebi are shown in **Figure 16**.

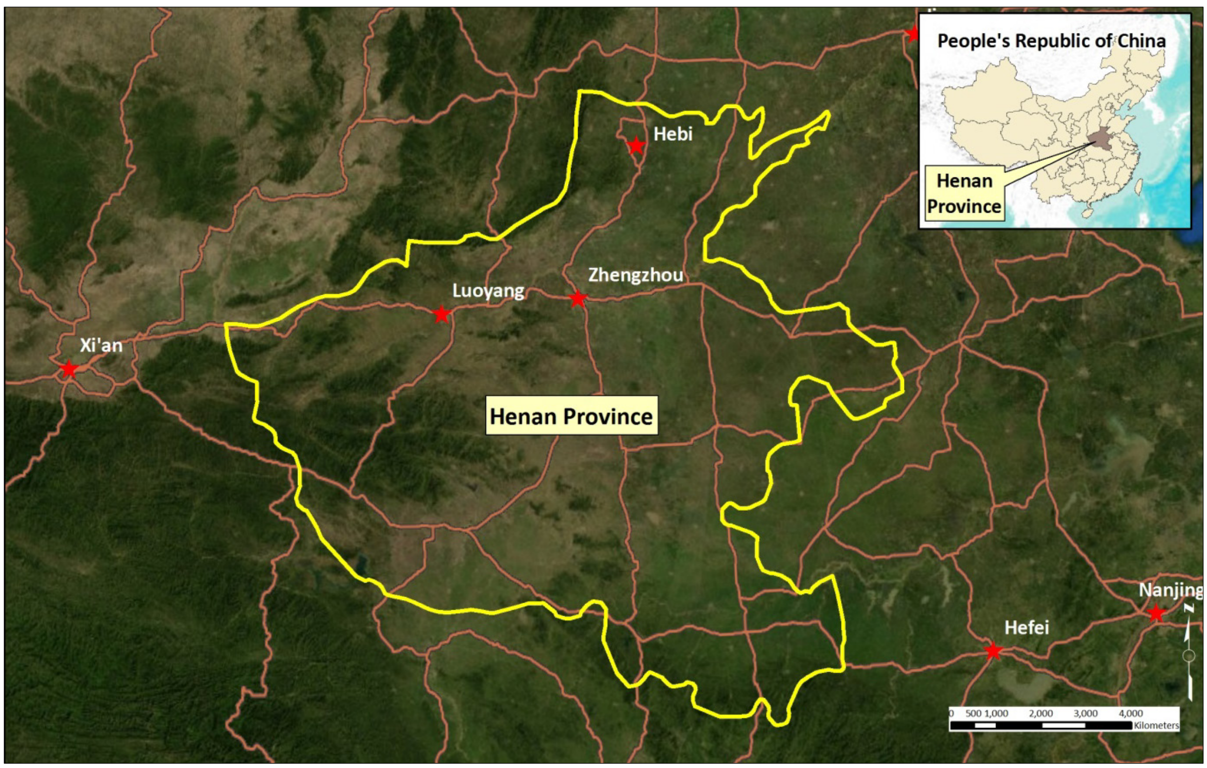

FIGURE 16: MAP SHOWING HENAN PROVINCE

Both supply and demand for coal in Henan fluctuated during 2005-2013 as shown in **Table 10**. While some of these changes were due to short-term factors, the province's transformation from net coal exporter to net coal importer is likely to endure.

TABLE 10: SUPPLY AND DEMAND FOR COAL IN HENAN, 2005-2013

	Production (million tonnes)	Consumption (million tonnes)
2005	187.61	184.68
2006	195.32	210.03
2007	192.87	231.71

2008	208.87	238.68
2009	230.18	244.45
2010	213.49	260.50
2011	187.2	NA
2012	158.78	252.40
2013	153.00	NA

Source: CESY 2013, pp. 222-223; CESY 2011, pp. 218-219; CESY 2010, p. 83; HSB 2011; HSB 2012; HSB 2013; Coal Research Network 2014

3.2.3.1 Supply and Industry Structure

Coal production in Henan, one of China's oldest coal producing regions, contracted by 77 million tonnes, or a factor of one third, between 2009 and 2013, as the province became a major net coal importer for the first time (**Table 10**). The bulk of the drop occurred in 2009-2012, while the boom market for coal was still in effect, and was the result of conscious policy decisions more than market forces.

As of 2009, approximately 40 percent of output originated from hundreds of low technology mines owned by sub-provincial government or township entities with less than 300,000 tonnes per year capacity and often with safety records that have attracted close attention by the provincial mine safety bureaus' safety records. Determined to rationalize production and improve safety, the provincial government, with strong central support, enacted a program that shuttered 250 mines producing less than 150,000 tonnes per year, and pushed for 498 mines producing between 150,000 and 300,000 tonnes per year to merge and reorganize under the leadership of five major modernized coal companies owned by the provincial government. A further 182 of these reorganized mines had been closed by the end of 2012, with another 77 recommended for shut down, and the remaining mines shuttered while undergoing safety recertification (China Medium and Small Enterprise Management and Technology, 2013).

As of 2012-2013, over 75 percent of provincial production originated from the following companies:

- The Henan Energy and Chemical Group based in the north and east of the province, owns both anthracite and bituminous mines reporting output of 45 million tonnes in 2012. (China Coal Society, 2013);
- The Yima Group in Western Henan, with approximately 18 million tonnes primarily of steaming coal output from 21 mines in Henan in 2012. In late 2013, this group was acquired by Henan Energy and Chemical (Yima Mining Group Credit Rating, 2014);
- The Zhengzhou Coal Group near the provincial capital, output 20.67 million tonnes in 2012 (Zhengzhou Mining Group Website); and
- The Shenhuo Group, a major aluminum producer based in Shangqiu, East Henan, with 15 million tonnes of capacity 2012 (Shenhuo Group website).

Overall, anthracite coal (sold primarily to power plants) accounts for about 40 percent of Henan's output, with coking coal 20 percent, and thermal bituminous coal the remainder.

The approximately one third drop in China coal spot market prices in 2012-2013 placed considerable financial pressures on Henan's major coal producers, saddled as they were with the extra costs associated with upgrading the smaller mines. The Zhongping group remained profitable due to the high percentage (40 percent) of its tonnage sold to steel mill coke ovens. The Henan Energy and Chemical group, which sells primarily thermal coal, lost money in 2013, with the profits from the Yongcheng subsidiary insufficient to cover losses from its other units, including Hebi (Henan Energy and Chemical Bond Prospectus).

Like other producers from long-established mining areas, Henan mines are not cost-competitive with the flood of new mines coming on-stream from new mining areas in Shaanxi and Inner Mongolia. Administrative guidance from the provincial government for Henan power plants to source coal in-province has given some protection to their market; however, pricing pressures are still present. Mining groups such as Hebi, which supplies a self-owned 1200 MW power plant which is adding an additional 1200 MW in 2014, is at least in a position to capture profit from their power plant investments. Like their counterparts in Anhui, the Henan producers are concentrating the bulk of their new investments in Inner Mongolia, Xinjiang to the north and northwest, and even Guizhou in the southwest, and may end up in effect subsidizing their Henan operations from new operations outside the province until prices improve.

3.2.3.2 In-Province Demand

After growing by approximately 8 percent per year during 2006-2010, coal consumption in Henan declined by about 8 million tonnes (equivalent to three percent) in 2011-2012. As shown in **Table 11**, the overall decrease resulted from the steep reduction in industrial and coke oven usage. Perhaps 3.5 to four million tonnes of the aggregate 27 million tonne decline in these sectors resulted from fuel switching to natural gas with industrial consumption increasing by 2.5 billion cubic meters in Henan over the same 2010-2012 period. The most important cause was the nationwide macroeconomic slowdown resulting from the end of the government stimulus program of 2009-2011 and restrictions on lending to real estate, which had a particularly strong impact on construction, exposing major overcapacity in major coal consuming sectors such as iron and steel.

Henan's industries faced serious competitive difficulties relative to some other regions; steel output contracted by 7.5 percent, output of non-ferrous metals grew by less than one percent, and flat glass output dropped by almost 40 percent between 2011 and 2012 (HSB, 2013). The shuttered capacity, furthermore, most likely belonged to the least efficient producers with the highest coal consumption per unit of output, magnifying the impact on coal demand. By contrast, generation by Henan's coal-fired plants, collectively the most important coal end-users in Henan, increased by an average 8.7 percent from 2010-2013. Substitution of large efficient generating units replacing smaller, less efficient ones meant that coal use grew at a slightly slower rate than power generation, though not as low as suggested by the gross tonnage figures in **Table 11**; possibly the average fuel value of coal burned by the power plants increased with Henan's growing use of high quality coal from Shanxi, Inner Mongolia, and Shaanxi. Coal-fired power generation in Henan can be projected to increase at perhaps six to seven percent per year for the three to four year future (Henan Electric Power Section, below), which would mean an additional 30-35 million tonnes of new coal demand (5500 kcal/kg).

Consumption in other sectors is more difficult to project and depends critically on overall macroeconomic trends. At some point, the overcapacity shakeout in sectors such as metals will be completed; Henan's steel output in fact rebounded sharply in 2013. As a populous inland province located relatively close to the major economic centers of the country, Henan's overall economy will likely continue to grow faster than the national economy as a whole as manufacturers relocate some facilities from the coast. However, the kind of manufacturing that relocates will not necessarily be of the high coal consumption type. **Figure 17** shows Henan's coal consumption by sector.

TABLE 11: COAL CONSUMPTION BY END USER, 2009-2012 (MILLION TONNES)

Thermal Power	94.0	104.6	115.4
District Heating	8.0	9.4	10.9
Loss in Coal Washing	15.3	16.29	19.3
Coking	29.0	35.9	31.6
Industry	81.9	82.9	59.3
Residential	10.7	7.9	11.4
Other	5.6	3.5	4.5
Total	244.5	260.5	252.4

Source: CESY 2013, pp. 222-223; CESY 2011, pp. 218-219; CESY 2010, pp, 182-183

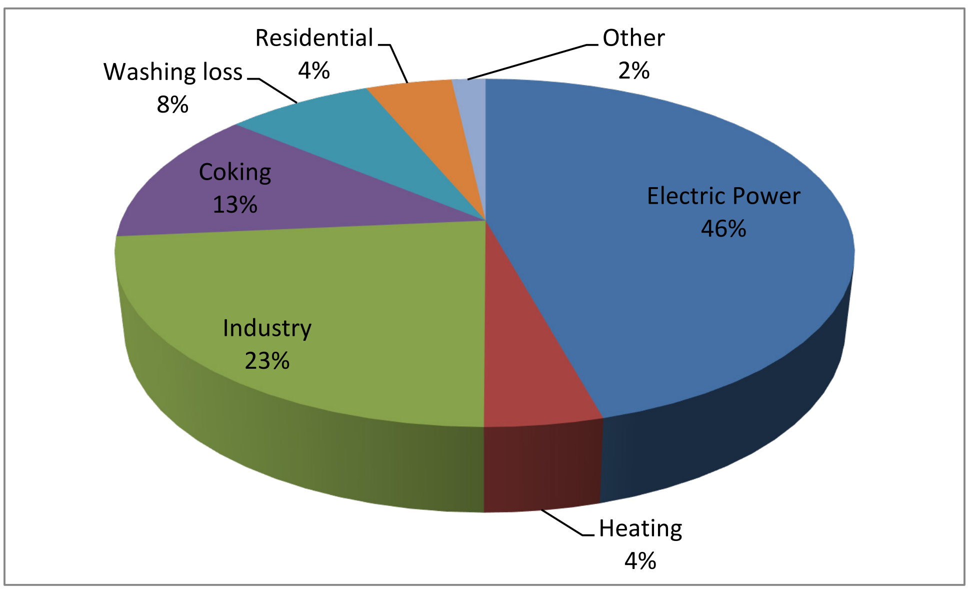

FIGURE 17: HENAN COAL CONSUMPTION BY END USER, 2012
Source: CESY 2013, pp. 222-223

3.2.3.3 Demand for Hebi Coal

Hebi's low volatile bituminous coal is suitable primarily for power plant and industrial use, with some output from its washing plant also injected into steel mill blast furnaces. An 1800 MW mine mouth power plant partly owned by Hebi Mining Group consumes four to 4.5 million tonnes per year. A 1320 MW addition to this plant is scheduled to come online in the 2015-2016 period, and should boost demand for coal by 2.5 million tonnes. An additional 4100 MW of coal-fired generating capacity are located within 60 km of Hebi, and thousands of additional megawatts of capacity are in various stages of planning (ChinaPower, 2014.1).

Prior to the plunge in coal prices, Hebi Mining Group supplied a reported 30 percent of the requirements of two of these plants with 1200 MW capacity located in Anyang City, a sign that it strives to maintain a diverse customer base rather than selling only to plants in the immediate vicinity. Like other large state-owned mines, it strove to maintain a balance between sales to traditional large customers under one-year contracts, and spot sales to customers of all kinds, which allow it to take advantage of the continuous rise in spot prices through 2011. With market prices dropping, the proportion of sales to the local power industry is undoubtedly higher.

3.2.4 Guizhou

Guizhou is a mountainous province located in southwestern China. Guizhou Province is shown in **Figure 18**.

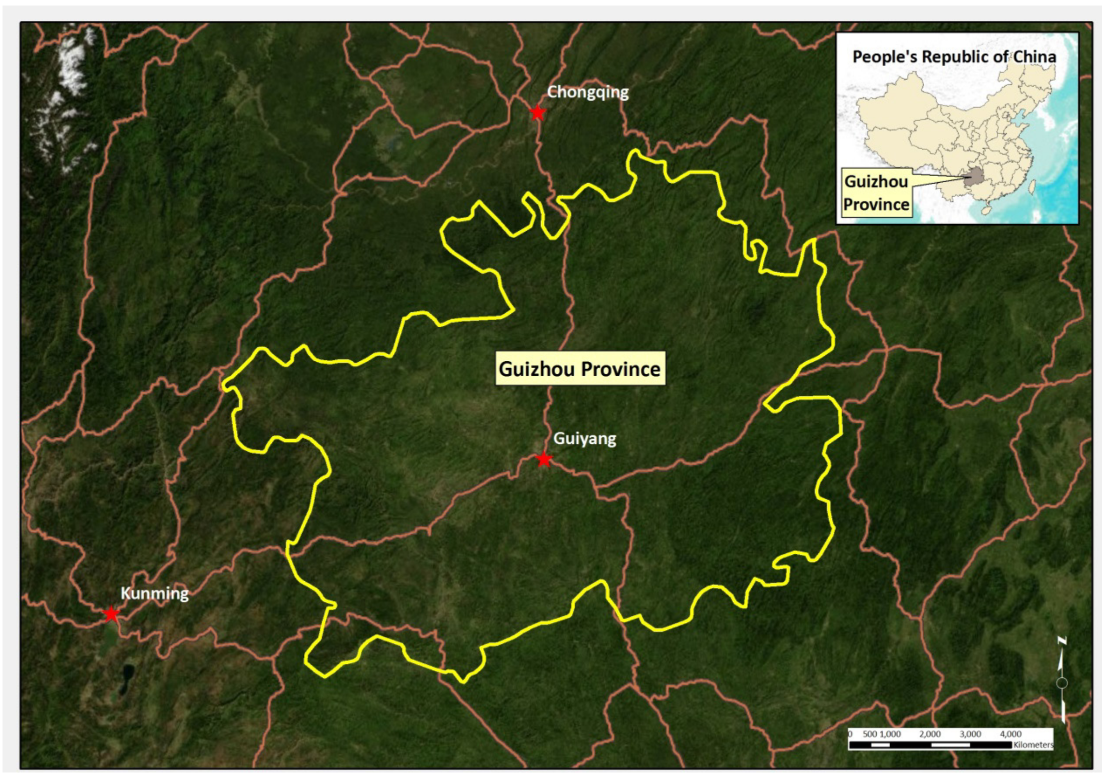

FIGURE 18: MAP SHOWING GUIZHOU PROVINCE

3.2.4.1 Supply and Demand

Guizhou accounts for approximately five percent of China's coal supply and perhaps three percent of its demand. Supply and demand from 2007-2012 are shown below in **Table 12**.

TABLE 12: GUIZHOU COAL SUPPLY AND DEMAND (MILLION TONNES)

Production	108.6	118.0	136.9	159.5	NA	181.1
Consumption	106.6	97.3	109.1	119	NA	133.3
Out of Province Sales	26.9	NA	27.5	40	NA	42.2

Source: CESY 2013, p. 270, CESY 2010, pp. 35, 83, 214; CESY, 2008, p. 214; CESY, 2006, p. 218; GSB, 2011; Guizhou Government Website, 2011

Guizhou has traditionally been a coal exporting province, shipping 25-30 million tonnes to outside customers in recent years. The Panzhihua Steel Mill in neighboring Sichuan Province is a major designated customer, consuming approximately 2.5 million tonnes of Guizhou coking coal, with most of the remaining shipments outside the province consisting of raw steaming coal sold in small lots to utilities and industrial facilities in Hunan, Chongqing, Sichuan and Guangxi. In addition to growth of consumption inside the province, rail transport bottlenecks have limited the volume of shipments outside the province (Gang123, 2009; Okuno, 2006).

Electric power accounts for close to half of Guizhou's coal consumption, with other industrial uses such as aluminum, chemical fertilizer feedstock, and coking accounting for most of the remainder (**Figure 19**). Residential consumption has declined steadily as urban residents have been hooked to the coal gas network, and now constitutes an insignificant percentage of the total.

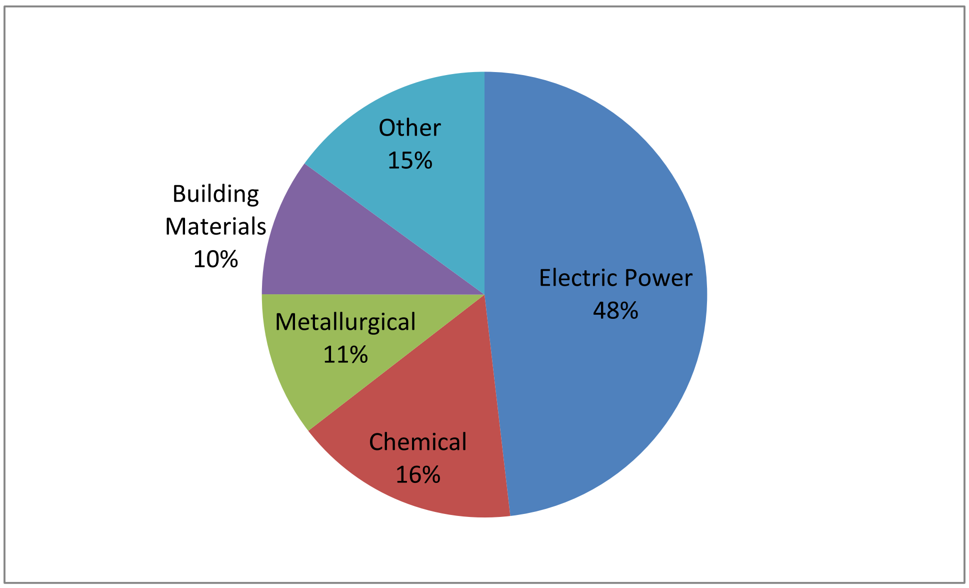

FIGURE 19: GUIZHOU COAL CONSUMPTION, 2010
Source: Guizhou Government (2011)

The Guizhou Coal Bureau has projected in-province demand growth at 11.5 percent per year from 2010-2015 to approximately 170 million tonnes, driven largely by the electric power plant construction program discussed in **Section 4.5.2**. The Bureau estimates that power plant demand will jump to as much as 58 percent of the provincial total by that time (Guizhou Government, 2011).

Based on known mine development plans, the Guizhou Coal Bureau targets provincial coal production to reach approximately 210 million tonnes in 2015, allowing for approximately 40 million tonnes of shipments outside the province. Even if in-province demand grows at a somewhat lower rate than the Bureau's projections, chronic coal shortages in the southern and western provinces surrounding Guizhou such as Guangdong, Sichuan and Chongqing, Hunan, and Yunnan, should ensure sufficient demand for all coal produced in the province assuming transport capacity is commensurately increased.

The proximity of Guizhou to these provinces makes its coal cost competitive with alternative sources in North China.

Guizhou's coal quality also makes it relatively attractive to neighboring provinces, especially vis-a-vis other southern and southwestern Chinese coals, much of which are high sulfur anthracite. Much of Guizhou's coal, by contrast is low-sulfur bituminous coal or semi-anthracite, and the province is virtually the only source of coking coal in south and southwest China.

3.2.4.2 Production

The Guizhou coal industry is spearheaded by three large, modernized provincially-owned companies established in the 1960s with current aggregate production of approximately 20 million tonnes, which typically sell under one-year contracts to their larger consumers: Shuicheng (10-11 million tonnes); Panjiang (13 million tonnes); and Liuzhi (3-4 million tonnes) (Guizhou Government, 2011). Remaining production, which now totals over 100 million tonnes, has traditionally come from hundreds of smaller, less mechanized mines owned at the sub-provincial level which sell under spot contracts. The quality of these coals, in particular their ash content, is also uneven compared to the larger mines in the province (Guizhou Daily, 2010; Shuicheng Mining Group Website).

The central government's drive to consolidate these smaller mines to a capacity level of at least 300,000 tonnes and to close the most dangerous and least efficient accounts for the temporary slump in production in 2007-2008 (**Table 12** above). The provincial and central governments are also making a concerted drive to introduce larger, better funded, and better managed investors to take the lead in new mine development. In addition to the three major in-province companies, these include companies such as the Shandong Yanzhou Coal Mining Group, which is developing a series of mines with aggregate capacity of over 12 million tonnes, as well as major utility coal consumers such as Nengfa's parent company China Power Investment.

3.2.5 Inner Mongolia

Inner Mongolia is a large province located in northern China. Inner Mongolia is shown in **Figure 20**.

FIGURE 20: MAP SHOWING INNER MONGOLIA

Coalfields and Production

TABLE 13: INNER MONGOLIA COAL PRODUCTION AND CONSUMPTION

Production	256	298	354	502	601	787	979	1,042
Consumption	140	162	186	222	240	NA	NA	366
Shipments to other provinces	128	NA	175	NA	384	NA	NA	711

Source: CESY 2013 p. 156, CESY (2009)

The stunning four-fold growth in Inner Mongolia's coal industry from 2005-2012 (**Table 13**), which has earned it a 25 percent market share in China and catapulted its output beyond that of all countries outside of China, results mainly from the Chinese government's decision to make huge amounts of inexpensive capital available for exploitation of the following almost virgin deposits.

Shenfu-Dongsheng and Zhunge'er is in Ordos Municipality in the western part of the province just north of the Shaanxi border. The 31,000 square km Shenfu-Dongsheng field, which overlaps Inner Mongolia and Shaanxi, has reported coal reserves of 223 billion tonnes. The Inner Mongolian portion of Shenfu-

Dongsheng, when combined with the neighboring Zhunge'er field, accounts for approximately half of these reserves. These deposits consist of high-quality steaming coal with high volatile (31-40 percent), low-ash (6-10 percent), low sulfur content (0.4-0.7) and thermal value of 23-24.5 MJ/kg, which is superior to most other coals in China. Mining conditions are also favorable, with little faulting, gently dipping, relatively shallow depth below surface (74-152 meters in a representative underground mine) and thick seams (4-7 meters is typical) (Guoha Power Corporation, 2005). The Zhunge'er field produces nearly 50 million tonnes per year from two open pit mines. With the addition of output from Shenfu-Dongsheng, Ordos Municipality as a whole mined 597 million tonnes of coal in 2011, which is over 60 percent of Inner Mongolia's output.

Shengli is in Xinlinhaote Municipality in the central part of the province, hundreds of miles north of Beijing. The deposit has reported reserves of 22.4 billion tonnes of lignite coal (approximately 13 MJ/kg) hundreds of meters thick. Two open pit mines (out of a total of 5 planned) produced approximately 50 million tonnes of coal in 2011. The Yuanbaoshan, Huoline, Yiminhe, and Zhalainuo'er lignite fields are in the northeastern part of Inner Mongolia adjoining Manchuria. These fields have been in production since the 1980s, but can still be mined by open pit. Together they produced over 100 million tonnes in 2011.

A number of smaller deposits have been mined for longer periods of time. The most significant of these include:

- Wuhai, in the city of the same name just west of Ordos and north of Ningxia Autonomous Region (Province), which produced approximately 12 million tonnes of coking coal in 2011.
- Alashan, including the Tai Xi mines west of Ningxia, which produced approximately 12 million tonnes of anthracite in 2011.
- Baotou and Huhehaote, near Inner Mongolia's two largest cities.

3.2.5.1 Development and Structure of the Inner Mongolia Coal Industry

The central government laid the groundwork for the Inner Mongolia coal boom in the 1990s through investment in a series of special use railroads to transport coal from the Shenfu-Dongsheng and Zhunge'er fields to the coast, from where it could be shipped to southern load centers:

- The Datong (Shanxi)-Qinhuangdao Por line runs 638 km, with its capacity upgraded to over 400 million tonnes by 2011.
- The Zhunge'er-Datong line runs 264 km, and transported 74.6 million tonnes in 2011.
- The Shenmu (Shaanxi)-Shuozhou (Shanxi)-Huangha Port line runs 854 km, and its capacity was upgraded to approximately 150 million tonnes 2011.

The latter two lines, as well as the Huanghua Port itself, are owned by the Shenhua Group and established by the central government for the special purpose of developing the Shenfu-Dongsheng coalfield. Through organic growth as well as government-supported mergers and acquisitions, Shenhua's production reached 400 million tonnes in 2011, placing it in the world's Fortune 500 companies (Shenhua website). Of this amount, about half came from the company's flagship subsidiary Shendong Coal Group operating in Shenfu-Dongsheng (estimated 80-90 million in Inner Mongolia, remainder in Shaanxi), including the 25 million tonne per year Bulianta mine, the largest underground mine in the world. A separate Shenhua subsidiary operates the two Zhunge'er open pits noted above, another one of the large Shengli deposit open-pits, and still others at older mines in Inner Mongolia (Shenhua website).

Many operators in addition to Shenhua have gained access to property in Ordos Municipality, including other major coal producers such as the Datong group and companies affiliated with various parts of the Inner Mongolian local government, and private companies that enjoy local government backing. While there is undoubtedly room for rationalization, a number of the mines run by the local companies are considerably larger scale and more modernized than the stereotypical local mines in the older mining areas which the central government is attempting to shut down. As many as 50 companies in Inner Mongolia produce 10 million tonnes per year or more.

While the bulk of the production in Ordos is shipped outside the province, Shenhua has also developed mine mouth power plants in line with its mandate from the central government. Conversely, the five national power generation companies have purchased coal assets in Inner Mongolia both for mine mouth plants and for use elsewhere, including the big lignite deposits in the northeastern part of the province.

3.2.5.2 Demand for Inner Mongolia's Coal

Outside of Inner Mongolia

The Inner Mongolian coal boom has been driven primarily by demand in the Yangtze Delta and southern coastal provinces. Shipments outside the province – overwhelmingly to these areas through the new railroads listed above – grew at a 32 percent rate from 2005-2009 (**Table 13**).

The overall economic slowdown and consequent collapse of the coal market boom throughout China in the first-half of 2012 has affected Inner Mongolia severely, with many mines reducing production, or even shutting down part time. The drop in price has brought about losses for a number of suppliers, including the large open-pit lignite mines (Coal Consulting Net, 2012; China Coal Resource, 2012).

While it is safe to predict that Inner Mongolia companies will benefit more than higher cost, lower quality producers in other provinces when the slump ends, it is difficult to predict how quickly this will happen, and what the longer-term changes in the pattern of demand for coal will be. If the economy experiences a soft landing and reorients somewhat away from investment towards consumption, and coal usage nationwide grows at 4-6 percent per year rather than 8 percent, it seems reasonable to project that the growth in demand for Inner Mongolia's coal would be an order of magnitude 10-15 percent per year rather than the 32 percent characteristic of the boom period. But it remains possible that a harder landing will constrain demand for a longer time and to a greater extent than has been previously anticipated.

One mitigating factor would be the opening of new domestic markets, in particular the inland Yangtze River provinces that Inner Mongolia has not served due to transport bottlenecks and the focus on supplying the coastal provinces. For the first time, there is serious discussion of a major north-south dedicated trunk railroad to transport coal to this region: a proposed 1847 km line from Erdos through Hubei and Hunan Provinces terminating in Jiangxi.

In August 2012, a variety of coal and railroad interests, including Shenhua, announced progress towards a commercial agreement to construct this line, noting that it is a “key project” of the central government’s Twelfth Five-year Plan. While the central government’s principal motivation would be to improve supply of high-quality coal to a resource-poor and chronically underserved area, the interests concerned are clearly motivated to find an outlet for Inner Mongolian coal during the economic slowdown (China Economic Net, 2012).

Inside Inner Mongolia

Compared to demand from other provinces, demand for Inner Mongolian coal in the province itself grew by a more modest but still substantial 14 percent annually from 2005-2009, led by the power sector, which accounted for nearly 60 percent of consumption (**Table 13**, **Figure 21**). The development of mine mouth power plants probably increased this growth rate somewhat through 2011. A variety of coal chemical plants built by the various mines may also have contributed to the increase. The contribution of industry is somewhat more modest than in many other more developed provinces.

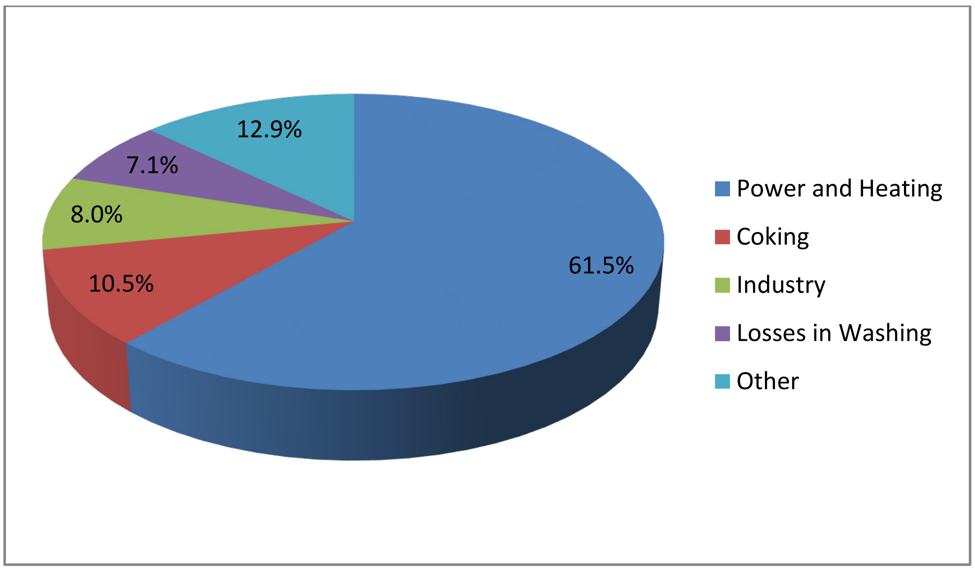

FIGURE 21: STRUCTURE OF COAL DEMAND IN INNER MONGOLIA, 2012
Source: CESY (2013)

The overall percentage of in-province consumption of Inner Mongolian coal still dropped from approximately 54 percent in 2005 to 35 percent or less in 2012. Even with continued expansion of mine mouth generating capacity, provincial demand by itself will not be sufficient to sustain the explosive expansion of 2005-2012. The emphasis in the Inner Mongolian Coal sector, therefore, will likely be consolidation and improved resource management as much or more as growth for its own sake.

4. Electricity Market

4.1 National Electricity Market

4.1.1 Growth in Demand

China's electricity consumption grew at a robust average rate of 9.7 percent from 2007-2012 (**Table 14**). With the exception of 2008-2009, during which the economy slowed down significantly in response to the world financial crisis and to tighter controls on real estate in China, growth in electricity consumption surpassed overall economic growth by an average margin of 19 percent.

In an investment-centered economy, industry was the primary driver of electricity, accounting for close to 73 percent of total consumption (**Figure 22**). Metals, building materials, and chemicals alone accounted for 37 percent, with residential with residential and commercial consumption accounting for only 20 percent.

TABLE 14: CHINA ELECTRICITY GROWTH, 2007 -2012

	2007	2008	2009	2010	2011	2012
Electricity Output (TWh)	3,281.6	3,466.9	3,715.7	4,206.5	4,700.0	4,987.5
Growth	*14.5%*	*5.6%*	*7.1%*	*13.2%*	*11.7%*	*6.1%*
Thermal	2,722.9	2,790.1	2,982.8	3,330.1	3,825.3	3,892.8
Growth	*14.9%*	*2.5%*	*6.9%*	*11.7%*	*14.8%*	*1.8%*
Hydro	485.3	585.2	615.6	721.0	694.0	872.1
Growth	*11.4%*	*20.6%*	*5.2%*	*17.1%*	*-3.9%*	*25.7%*
Nuclear	62.1	68.4	70.1	73.9	86.4	97.9
Growth	*13.3%*	*10.1%*	*2.5%*	*5.3%*	*16.9%*	*13.1%*
Electricity Capacity (GW)	713	804	874	962	1,050	NA
Growth	*14.4%*	12.7%	*8.7%*	*10.1%*	*9.1%*	

Source: CESY (2008, 2010, 2013), p. 75, p. 129; NBSC (2008); NBSC (2007.1), Table 5, NBSC (2008.1), Table 5; NEA 2012; CEPY (2007, p. 625); NBSC (2012)

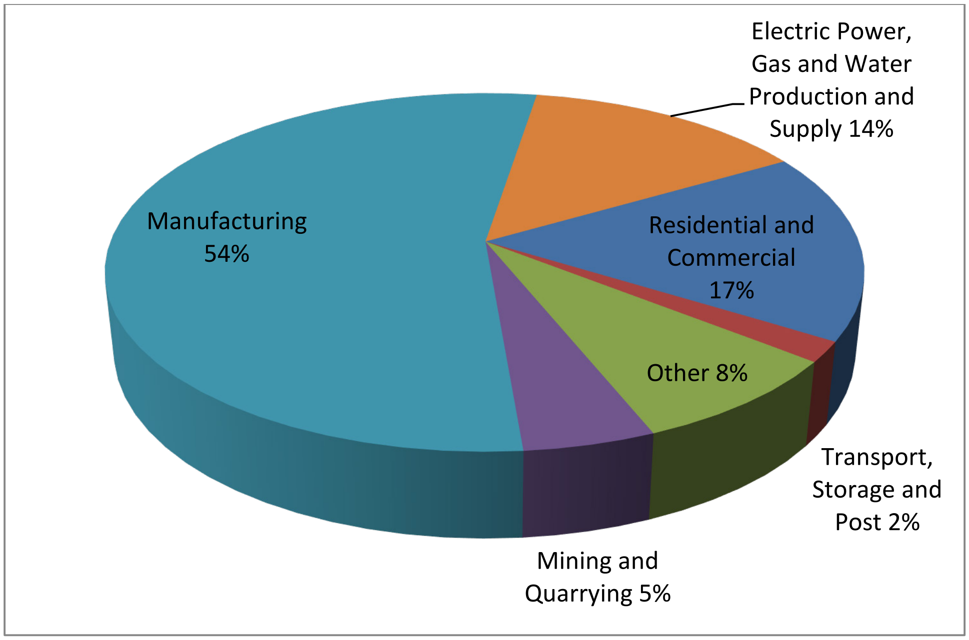

FIGURE 22: ELECTRICITY CONSUMPTION BY SECTOR, 2012
Source: CESY (2013) p.86

Changes in the pattern of growth during the Twelfth Five-year Plan period (2011-2015) will bring about changes in the rate of growth of electricity consumption, and in the relationship between economic growth and electricity consumption.

Starting from the second quarter of 2012, economic growth slowed down significantly in response to the recession in major export markets and government clampdown on an overheated property sector that caused the slowdown of 2008-2009. As growth in Gross Domestic Product (GDP) dipped to a reported 7.6 percent level in second quarter 2012, many observers understated the severity of the slowdown. Growth in electricity output dropped to an average 1.6 percent level from March-July (NBSC, 2012.2).

The slowdown was partially cyclical in nature, but it was not clear in mid-2012 how hard the landing would be, or how much time would be required for a rebound to occur. The prospects for growth in the major developed country export markets remained uncertain, and the Chinese government appeared reluctant to loosen real estate controls too quickly or to undertake a major infrastructure stimulus program similar to the one of 2008-2011 for fear of continuing to inflate an asset bubble.

Observers inside and outside China agreed that even after the worst of the cyclical downturn had passed, the events of 2012 likely heralded longer-term structural change that would gradually shift the balance of the economy away from investment and towards consumption. The World Bank projected approximately 8.5 percent economic growth, and the Twelfth Five-year Plan projected 7.5 percent through 2015 (Xinhuanet, 2011; World Bank, 2012).

Given the lack of precedent, it is difficult to project how rapidly electric power consumption would increase under conditions of sustained, balanced 7.5-8.5 percent economic growth. The experience of 2008-2009 and mid-2012, during which economic growth dropped to the 6.1-7.6 percent range and electricity consumption increased at only half the rate of the economy as a whole, may not be a useful guide, given the possibility that the official statistics may have overstated economic growth and the suddenness of the contraction.

As of mid-2012, the government had not released a Twelfth Five-year Plan for the electricity industry. The closest to an official projection came from the "Electricity Industry Rolling Report for the Twelfth Five-year Plan" issued in March 2012 by the China Electricity Council (before the depth of the 2012 slowdown became clear), which stated that electricity consumption would increase on average by 7.5-9.5 percent per year from 2011-2015. The mid-point of this range would yield a 1:1 ratio between economic and electricity growth according to the growth projections of the World Bank in early 2012, and the lower end would yield a 1:1 ratio between electricity growth and economic growth according to the growth projections of the Twelfth Five-year Plan (China Electricity Council, 2012).

Growth in electricity consumption by the service sector and by households can be expected to increase somewhat faster than in the past given accelerating urbanization and higher overall consumption. The key question facing the electricity sector is how fast industrial demand will increase as overall growth moderates. A 1:1 ratio in electricity growth relative to economic growth, as compared to the 1.2-1.3:1 ratio in the 2000-2010 period seems a reasonable estimate, but there is considerable potential for variance in either direction given the number of unknowns.

4.1.2 Status of the Electricity Industry, 2012

4.1.2.1 Generation

As China is a zero importer/exporter of electricity, its growth has come entirely from domestic generation, with output and generating capacity increasing by average 11.1 and 12.5 percent annually 2005-2011 (**Table 15**) to 4,700 Terawatt Hours, and 1,060 Gigawatts respectively. Thermal power, overwhelmingly coal-fired, dominates the generation mix (**Table 15**):

TABLE 15: POWER OUTPUT AND CAPACITY BY TYPE, 2011

Thermal	760	72.4	3,825.3	81.4%	5294	60.4
Coal Fired	710 (est.)	67.6	NA	NA	NA	NA
Gas-Fired	40	3.8	NA	NA	NA	NA
Hydro	230	21.9	694.0	14.8%	3028	34.6
Nuclear	12	1.1	86.4	1.8%	7772	88.7
Wind	47	4.5	73.2	1.6%	1903	21.7

Source: China Electricity Council (2012); NEA (2012)

The majority of coal-fired capacity added since 2005 consists of high-efficiency supercritical units of 600 MW capacity or above. As of 2011, 39 ultra-super-critical units of 1000 MW were in operation (primarily in coastal provinces), with dozens of others under construction. Thermal units operated in 2011 for an average of 5294 hours out of 8760 possible, an approximately 60 percent capacity factor (NEA, 2012).
The 26-unit, 22,500 MW Three Gorges megaproject on the Yangtze River in Hubei Province accounted for a full 10 percent of hydropower capacity. Nuclear capacity consisted of 14 units in four stations, with over half located in Shenzhen, Guangdong Province across the Hong Kong border in base load operation.

Over two thirds of the 47,000 MW of wind power installed as of 2012 came online after 2009 in response to a series of incentives and directives from the central government. These facilities, consisting primarily of 1000 or 2000 KW generating units, are spread across a broad area north of the Great Wall running from Northeast Inner Mongolia to Xinjiang, with approximately one third located in Inner Mongolia where the wind regime is most favorable. Massive farms of 10,000 MW capacity are under development in several locations. Capacity utilization factor, however, is low even by the standards for wind power plants, due to a combination of failure to extend transmission infrastructure as quickly as plants have been built, and the complexity of dispatching wind power plants in the winter, when coal-fired cogeneration stations must be run at close to full load in order to provide power to urban buildings.

4.1.2.2 Organizational and Geographical Overview of the Power Sector

When ownership of transmission and generation assets was separated in 2002, the government established five large generation groups of national scope to take over existing plants and build new ones:

- Guodian (National Electricity) Group
- Huadian (China Electricity) Group
- Datang Group
- Huaneng Group
- China Power Investment (CPI)

Each group operates throughout China, and together they own the vast majority of the large thermal plants, and a portion of the large hydroplants. The central government ensures that there is a rough balance among them through its project approval process.

Two specialized hydropower companies, independent of the five groups, operate the country's largest hydropower plants:

- The Three Gorges Group Company, which controls the Three Gorges project itself as well as a series of four stations planned or in operation on the Upper Yangtze, has 43,000 MW aggregate capacity.
- The Ertan Hydropower Company jointly controlled by the China Investment Company and Sichuan Provincial interests which, in addition to operating the Ertan 3,300 MW station itself, is responsible for developing a series of plants totaling tens of thousands of megawatts on the Yalong River and its tributaries in Sichuan.

Nuclear power plant ownership follows a somewhat similar pattern, with two specialized companies with nuclear technology capabilities holding controlling interest and operational responsibility: China Guangdong Nuclear Power Company and China National Nuclear Corporation. The five major power generation companies typically hold minority shares in these plants.

Provincial and sub-provincial government companies such as Chongqing Energy Investment Corporation own minority shares in most of the plants of the five major groups and the two hydropower companies. A select number of provincial companies such as Yudean Group (Guangdong) and Anhui Energy

Company have controlling interests in large base-load power plants located in or dedicated to their localities. The grid-connected small-scale hydropower and renewables plants are owned by a plethora of central government, local government, and private interests.

The Shenhua Group, China's largest coal mine operator, was permitted by the central government to enter the power generation business in the 1990s, and by 2012 had grown its portfolio (including plants in which it had a minority interest) to almost 43,000 MW of coal-fired and wind power plants. Spurred by rapidly escalating coal prices from 2008-2011 which created severe financial problems for the five major generators, the central government began to further promote vertical integration of coal and power companies. While there were several highly publicized cases of coal companies acquiring power generation assets, it remained to be seen in 2012 how deeply this trend would take hold.

Finally, a portion of China's generation assets consist of off-grid plants owned by industrial enterprises, or sub-provincial governments. In some areas such as Chongqing, these plants account for as much as 5-10 percent of total generation.

4.1.3 Transmission, Distribution, and Geographical Layout of the Power Sector

Transmission and distribution for the public grid is at present a duopoly of two major state-owned holding companies: (1) State Power Grid Company of China (SGCC), with responsibility for the Northeast China, North China, Northwest China, and Central China Grid areas; and (2) the China Southern Power Grid Company (China Southern) responsible for the grids in Guangdong, Guangxi, Guizhou, Yunnan, Tibet, and the island province of Hainan. The SGCC operates four transprovincial grid company subsidiaries corresponding to the regions mentioned above; these companies, together with China Southern operate trans-provincial transmission lines (**Table 16**).

TABLE 16: OVERVIEW OF REGIONAL GRIDS, 2011

	Provinces Covered	Total Power Consumption (GWH)	Total Power Generation (GWH)
STATE POWER GRID CORPORATION			
North China Power Grid Corporation[1]	Beijing, Tianjin, Hebei, Shanxi, Shandong, Western Inner Mongolia	1132.4	1108.6
Northeast China Power Grid Company[2]	Liaoning, Jilin, Heilongjiang, Northeast Inner Mongolia	361.2	366.4
East China Power Grid Company[3]	Shanghai, Jiangsu, Zhejiang, Anhui, Fujian	1147.1	1098.6
Central China Power Grid Company[4]	Henan, Hubei, Hunan, Jiangxi, Sichuan, Chongqing	867.3	898.6
Northwest China Power Grid Company[5]	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang	400.4	462.0
CHINA SOUTHERN POWER GRID CORPORATION[6]	Guangdong, Guangxi, Guizhou, Yunnan, Hainan, Tibet	784.6	787.2

1: Inner Mongolia and Shanxi are major power surplus provinces, the others are deficit provinces
2. Liaoning is a major power deficit province, the others are surplus provinces
3. Anhui is a significant power surplus province; Shanghai, Jiangsu, and Zhejiang are deficit provinces
4. Hubei and Sichuan are power surplus provinces, the others are deficit provinces
5. All provinces except Qinghai are power surplus provinces, largest surplus is from Shaanxi
6. Guangdong is significant power deficit province, Guizhou and Yunnan significant surplus provinces
Source: State Electricity Regulatory Commission (2012)

Subsidiaries of the regional grid companies operate provincial grid companies responsible for in-province transmission and local distribution. In certain cases such as Hebei Province, which is split into one grid covering the northern part of the province together with Beijing and Tianjin and a separate Southern Hebei grid, the reporting units to the transprovincial grid companies are sub-provincial companies.

With one exception, the provincial grid companies are wholly owned by the regional grid companies under SGCC and China Southern, without provincial government participation. Only the Western Inner Mongolia Grid Company reports to the provincial government.

All grid connected power plants sign power purchase and dispatch agreements with one of the grid companies. Dispatch is a complicated process involving both the provincial and the regional grid companies, with the former mainly responsible for dispatch of in-province power plants, and the latter responsible for trans-provincial dispatch.

In virtually all provinces of China the majority of the power consumed is generated and dispatched within the province, out of concern for security of power supply. The major coastal provinces depend on coal (and, to a much smaller extent, uranium and natural gas) shipped from the interior by rail and water to fuel the plants.

Environmental and land use concerns, however, are becoming increasingly influential in power plant siting decisions. In a growing number of cases, therefore, large hydropower and thermal power plants in provinces with power surplus are connected directly via dedicated transmission lines to grids in large load, power deficient provinces, and sell all or most of their power to these provinces under agreements brokered by the relevant provincial governments and companies, regional grid companies, and the central government. Examples include a series of major hydropower and coal stations in Guangxi, Guizhou, and Yunnan Provinces which sell to Guangdong Province, the 4200 MW Inner Mongolia Tuoketuo plant which sells directly to the Beijing-Tianjin-Hebei grid, the 2200 MW Yangcheng Plant in Southeastern Shanxi which sells to Jiangsu, and a series of thermal plants in Anhui Province that sell to Shanghai, Zhejiang, and Jiangsu.

Since 2002 the central government has made these projects a cornerstone of one of its key economic and political priorities: the economic development of poor but resource-rich interior provinces and their integration with the richer, more populous but resource-poor coastal provinces. The term “West-to-East” is therefore used to describe these power plants and transmission lines, as well as most of China’s major gas pipelines.

For the most part, the electricity transfers from these projects take place between provinces within a territory covered by one of the regional grid companies under SGCC, or within China Southern, rather than between regional grid companies. As can be seen from **Table 16** the regional grid companies have been basically self-sufficient, and electricity exchanges between the regional grids have been minimal.

Already in 2011, the provinces in the East China Grid Company relied on 500 kV dedicated transmission lines from the Three Gorges Power plant in the Central Grid Company territory and from the above-mentioned Yangcheng plant in North China grid territory for about four percent of its needs. The North China Grid relied on dedicated 500 kV transmission lines from specific plants in Shaanxi and Ningxia (Northwest grid territory) for about 2-3 percent of its needs.

As of 2012, the SGCC also had completed three experimental ultra-high voltage (UHV) transmission lines capable of transmitting over 5000 MW of power connecting regional grids:

- A 1000 kV UHV alternating current (UHVAC) line Southeast Shanxi-Jingmen, Hubei;
- A +/-800 kV ultra-high voltage direct current (UHVDC) line Xiangjiaba Hydropower Plant, Sichuan-Shanghai; and
- A +/- 800 kV UHVDC line from Jinping hydropower station, Sichuan -Jiangsu (JDRC, 2012; China Energy Net, 2011; TD World, 2012).

The SGCC’s ambition to undertake construction of an extensive UHV network by 2010-2015 is a major subject of discussion and debate in electricity industry planning.

4.2 Electricity Macro Plans

4.2.1 Generation Mix

The China Electricity Council's (CEC) Rolling Projections for the Twelfth Five-year Plan from 2011-2015 projected an average 7.5-9.5 percent annual consumption (and therefore generation) growth over the course of the plan. Based to a significant extent on ongoing construction and planning for specific projects, the Council foresees an average 8.6 percent per year increase in generating capacity to 1,463 Gigawatts, broken down roughly as follows in **Table 17.**

TABLE 17: ELECTRICITY GENERATION CAPACITY INCREASE, 2011-2015

Coal	710	928
Natural Gas	40	50
Hydropower	230	301
Pumped Storage	13	41
Nuclear	11.9	43
Wind	47	100
Solar	NA	5
Other (biomass, etc.)	NA	5
Total	1,060	1,463

Source: China Electricity Council (2012); NEA (2012.2)

According to these projections, installed coal-fired generating capacity will increase at an average annual rate of 7 percent from 2011- 2015, somewhat slower than in earlier years. All indications are that since 2009-2010, construction applications for new large coal-fired power plants have been subjected to more careful scrutiny by the central government, particularly in the big coastal provinces. The number of units approved for construction is often lower than the number applied for, and the approvals are contingent in many cases upon the retirement of older, smaller scale, less efficient generating facilities. Power plants in the coal-rich North and Northwest (including Xinjiang in the far northwest) appear likely to account for significantly larger percentage of new capacity than in previous years.

The National Energy Administration's (NEA's) Twelfth Five-year Plan for Renewable Energy puts forth somewhat more conservative targets for hydropower capacity increase compared to the Electricity Council's rolling plan: 260,000 MW of conventional hydropower instead of 301,000 by 2015, and 30,000 MW of pumped storage hydropower instead of 41,000. Given the long lead-times for hydropower plant construction, almost all of the capacity that will be onstream by 2015 was already under construction by the time the NEA's plan was issued.

The NEA is clearly committed to increased hydropower construction over the longer term, with its Twelfth Five-year Plan calling for the scale of hydropower construction to reach 160,000 MW during 2010-2015, and for total installed hydropower capacity to rise to 400,000 MW by the year 2020. The bulk of capacity will be added in the major rivers in the mountainous parts of West China, including for the first time Tibet, made possible by technical advances and large investments in transmission facilities.

The CEC's Rolling Plan projects that 24.9 percent of China's power output will come from plants that do not burn fossil fuels, up about five percent compared to 2010-2011. As hydropower plant capacity is targeted to rise at approximately the same rate as coal 2010-2015, coal fired electricity will actually lose its market share primarily to nuclear power and wind power under this scenario.

The plan's nuclear capacity projection of 41,000 MW in 2015 implies that nuclear capacity will increase by approximately 31,000 MW 2011-2015 (**Table 17**). This ambitious target is achievable if the projected construction schedules for the 11 coastal plants launched prior to 2010 do not slip. If overall electricity production grows at about 7.5 percent overall, and nuclear power continues to be base loaded at approximately 7700 hours per year (close to 50 percent higher capacity factor than coal and about 250 percent higher than hydropower), nuclear power could account for as much five to six percent of total generation by 2015-2016, even though it will account for only about 2.8 percent of generating capacity.

In early 2011 prior to the Fukushima nuclear disaster in Japan, the then-Director of the NEA predicted that nuclear power generation capacity could rise to 86,000 MW by 2020. In the wake of the incident, however, the Chinese government issued a moratorium on approval of new nuclear construction projects pending a comprehensive safety survey of projects already in operation or under construction and implementation of mitigation plans for all problems identified by the survey. As of third quarter 2012, the survey had been completed and mitigation plans drafted, but the moratorium had not yet been lifted.

The difficulties of installing additional coal-fired capacity in coastal areas, pressure to reduce carbon emissions, as well as a strong nuclear industry lobby suggest that a nuclear program of significant scale will resume in China. Industry insiders were reported to believe in mid-2012 that nuclear capacity in 2012 would be in the 60,000-70,000 MW range, rather than the 86,000 MW predicted before the Fukushima nuclear disaster (Beijing News, 2012).

The government intends to sustain the drive to rapidly develop non-hydropower renewable electricity sources. The 2010 Renewable Energy Law gives the government the authority to require the grid companies to purchase a fixed percentage of their wholesale electricity from renewable resources. Media reports in 2012 indicated that deliberations to fix the first targets under this legislation were in an advanced stage.

According to the Twelfth Five-year Plan for Renewable Energy released by the NEA, approximately two thirds of the 53,000 MW of new wind power capacity is targeted to come from large concentrated complexes of 2,000-5,000 MW scattered across sparsely populated areas with good wind conditions north of the Great Wall ranging from Northeast Inner Mongolia and neighboring areas of the three Manchurian Provinces, through Hebei, Western Inner Mongolia, and Gansu to Xinjiang. The Administration hopes that an additional 10,500 MW (including initial offshore demonstration complexes) can be constructed along the Shandong and Jiangsu Provincial coast, closer to major load centers (NEA, 2012.2). The plan stresses the importance of developing less concentrated, more distributed wind resources in central and southern inland areas, including small farms near substations of less than 110 kV capacity for use in local areas.

The fulfillment of this goal will depend on the willingness of the grid companies, which have made substantial progress towards absorbing power from the major wind farms, to comply with stated central policy and law. This means accepting the burden of dispatching small plants with varying output even as the power system as a whole becomes increasingly dependent on large base-loaded coal and nuclear units, as well as large hydropower plants. The progress in this transformation has major implications for most CMM generating facilities, whose highly distributed nature and fluctuating output closely mirrors the conditions of wind and solar complexes.

Plans for grid-connected solar power plant construction are split roughly in half between relatively large concentrated complexes in the far west and northwest and more scattered, distributed stations in economic development zones such as industrial parks, who would produce mainly for their own use, but would be permitted to sell excess to the grid. The latter category also includes some construction on islands or in other remote areas which the public grid cannot reach. The enforcement of grid off-take requirements and the development of a more distributed power-friendly culture within the grid companies will be essential to the full success of the plan.

Government and industry projections for renewable power utilization rates remain modest. The various plans assume continued wind power plant annual operation of 1900 hours, equivalent to an approximately 22 percent capacity factor. Overall, the percentage of power generated from non-hydropower renewable energy will likely be in the vicinity of four percent of the total by 2015, even as the renewable percentage of installed capacity rises to as much as 10 percent.

4.2.2 Grid Integration

The SGCC has drafted ambitious plans to deepen the integration of the public grids under its jurisdiction (Northeast China, North China, Northwest China, East China and Central China) in order to optimize dispatch, remove bottlenecks, and facilitate the development of rich coal, hydropower, and wind energy resources in remote western areas. The cornerstone of the plan it submitted to the NDRC in 2012 is the immediate construction of three major UHV AC and three UHV DC transmission lines running from Inner Mongolia to the south and from Sichuan and Xinjiang to the east which would create conditions for the amalgamation of the North, East, and Central grids into one operating unit (China Stock Net, 2012).

The plans to amalgamate have generated controversy within the electricity industry regarding the vulnerability of such a large area to shut down in the event of an accident in one location, and the overconcentration of authority and power within the SGCC. Questions have also been raised about the costs, benefits, and risks of the UHV technology, for which there are few reference projects other than the experimental projects put into commission by the SGCC itself in the 2010-2012 period. After experimenting with UHV, a number of nations including Japan and Italy have decided it is not economically feasible as existing UHV transmission lines are operating at lower voltage because of lack of demand (New Century Magazine, 2011).

As of mid-2012, it appeared that the NDRC would permit certain UHV lines to move forward, but would not approve the plan as a whole in the short-term. Due to particular concerns within the industry regarding the stability of AC UHV lines, observers predicted that the DC lines would proceed at a faster pace.

Three lines were permitted to start construction in the first half of 2012:

- A 1000 kV AC line linking the coal generation plants in the Huainan area of Anhui Province to major load centers in Shanghai and Zhejiang.

- A 2200 km, +/- 800 kV DC line linking the coal and wind-rich Hami area of Xinjiang to Zhengzhou, Henan Province, with the capacity to transmit the equivalent of 8000 MW of power due online in 2014.
- A 1670 km, +/- 800 kV DC linking the 12,600 Xiluodu hydropower station in Sichuan to Zhejiang, anticipated to transmit an average of 4500 MW. (SGCC, 2012; SGCC, 2012.1; Rednet, 2012).

4.2.3 Electricity Price

Through the NDRC, the Chinese central government tightly controls most electricity wholesale prices and all wholesale, transmission and retail sales prices under a “cost plus profit” approach with a target rate of return of about eight to 10 percent. Balancing the interests of generators and distributors with those of the various categories of end-users in an environment of acute sensitivity to macroeconomic price stability, poses great practical challenges. There is no fixed schedule for tariff adjustments, which are made on average about once every 18-24 months.

Rapidly escalating coal costs have frequently put pressure on the electricity cost structure, with generators bearing the brunt of the burden, in the absence of a mechanism to pass the increases onto to SGCC and China Southern, and to these grid companies’ end-users. In a number of years, including 2011, generators have claimed losses due to coal pricing issues.

Reforms to the pricing system, including competition among generators and separation of thermal tariffs into capacity and dispatch components, differential peak and off-peak pricing, among others, have been discussed or attempted on an experimental basis in isolated locations. But as of 2012, none had been adopted on a comprehensive basis.

4.2.3.1 Wholesale Prices

Thermal

Wholesale coal-fired power prices charged to the grid companies are fixed by the NDRC on a province-by-province basis based on prevailing coal costs, regardless of the size and efficiency of the plants (**Table 18**). Given the prevalence of coal-fired power, these prices are often used as a benchmark for the electricity industry as a whole.

The national average in third quarter 2012 was somewhat over 0.4 CNY per kWh; prices are less expensive in the large coal-producing provinces than in the coastal provinces, but the differential has narrowed since 2008 as local coal prices in the coal producing provinces have raised substantially. The published prices include a 0.015-0.02 CNY per kWh charge to recover costs related to flue gas desulfurization, which is mandatory for most coal generating stations, as well as 17 percent value added tax (VAT).

The prices for gas-fired combined cycle power plants are set in many localities by the local government price bureaus rather than directly by the NDRC, thus there is somewhat more variability in structure. In Shanghai, for example, a tiered capacity and generation charge system has been implemented. The average price is around 0.55 CNY per kWh, as much as 20-40 percent higher than coal-fired prices. Only in Guangdong Province, which fixed imported LNG prices in 2002, were LNG-fired combined cycle power plants competitive with coal-fired plants in 2012; they were substantially higher, however, than prices for thermal and hydropower shipped from Guizhou and Yunnan.

TABLE 18: WHOLESALE POWER TARIFFS FOR THERMAL POWER PLANTS IN CHINA, SEPTEMBER 2012

Region	Province	Coal-Fired, including flue gas desulfurization: CNY/kWh	Natural Gas-Fired Combined Cycle: CNY/kWh
North China	Beijing	0.400	0.573
	Tianjin	0.412	NA
	Hebei North Hebei South	0.424 0.430	NA
	Shanxi	0.374	NA
	Shandong	0.445	NA
	Inner Mongolia Self-Use To Beijing grid	0.311 0.373-0.375	NA
East China	Shanghai	0.477	0.71 (up to 2500 hours) 0.3665 (increment above 2500 hours)
	Jiangsu	0.455	0.581
	Zheijiang	0.482	NA
	Anhui	0.446	NA
	Fujian	0.445	NA
Central China	Hubei	0.478	NA
	Hunan	0.501	NA
	Jiangxi	0.485	NA
	Henan	0.419	0.554
	Sichuan	0.449	NA
	Chongqing	0.444	NA
South China	Guangdong	0.521	0.533
	Guangxi	0.477	NA
	Yunnan	0.353	NA
	Guizhou internal use Guizhou To Guangdong	0.373 0.383	NA
	Hainan	0.490	0.395

Source: NDRC (2011.6), (2011.8), (2011.9), (2011.10); Shanghai Price Bureau (2012); Suzhou Municipal Price Bureau (2012); Xinhuanet (2011.1)

Hydropower

Wholesale prices for electricity generated by large hydropower plants and some small hydropower plants are fixed by the NDRC on a plant-by-plant basis, with the remainder fixed by the local government price bureaus. These prices vary substantially according to location, hydrological conditions, and the era of construction (**Table 19** below). As these plants are not affected by rising fuel prices, adjustments and changes are both less frequent and of substantially smaller magnitude.

The prices for large hydropower plants built prior to 1995 on the Yellow River in the north and northwest and on the Yangtze, Pearl, and Mekong tributaries in central and western China, tend to fall in the 0.15-0.25 CNY per kWh range, approximately 33-55 percent of that for coal-fired power. Plants of more recent vintage on the western rivers (with the exception of the Mekong, which remain close to earlier levels) are allowed for the most part to charge in the 0.30-0.40 CNY per kWh range, about 67-90 percent of the level for coal.

The wholesale prices charged to the coastal provinces for recently constructed hydropower stations on distant western rivers include substantial premiums to cover costs of transmission line construction. The transmission component for the prices paid by Shanghai and Guangdong for power from the Three Gorges station, for example is approximately 0.11 per kWh, equivalent to 25 percent of the total price.

TABLE 19: WHOLESALE TARIFFS FOR SELECTED HYDROPOWER STATIONS IN CHINA, SEPTEMBER 2012

Station	River	Tariff (CNY per kWh)	Date of completion
Danjiangkou, Hubei Province	Han River, Yangtze Tributary	0.195	1970s
Lubuge, Yunnan Province	Huangni River, Pearl River Tributary	0.166	1980s
Sanmenxia, Henan Province	Yellow River	0.242	1950s
Longyangxia, Qinghai Province	Yellow River	0.145	1980s
Ertan, Sichuan Province	Yalong River, Yangtze Tributary	0.275	1990s
Three Gorges, Hubei Provinces	Yangtze River	Local: 0.3127 Shanghai: 0.3824 Guangdong: 0.4109	2005-2012
Longtan, Guangxi Province	Hongshui River, Pearl River Tributary	Local: 0.295 Guangdong: 0.395	2010
Chongqing Hydropower plants larger than 50 MW	Yangtze River Tributaries	0.32-0.33	Various
Goupitan, Guizhou Province	Wu River, Yangtze River Tributary	0.297	2005-2010

Source: NDRC 2006.2, 2008.1.a, 2008.2, 2008.4, 2008.5, 2009.3, 2009.4

Nuclear

Nuclear power plant wholesale prices are fixed by the NDRC in coordination with the highest levels of the central government. Tariffs for the three stations onstream in third quarter 2012 (**Table 20**) range from about 80 percent of coal-fired prices (Guangdong Ling'ao and Zhejiang Qinshan Phase II) to equivalency with coal-fired prices (Jiangsu Tianwan).

The gradual localization of nuclear power plant technology has been expected to lower tariffs by as much as 25 percent. Stricter safety measures in the wake of the Fukushima disaster may upset these calculations.

TABLE 20: CHINA NUCLEAR POWER PLANT WHOLESALE TARIFFS, SEPTEMBER 2012

Plant	Tariff (CNY/kWh)	In-Province Coal-fired Power Plant Tariff (CNY/kWh)
Ling'ao, Shenzhen, Guangdong Province	0.432 (up to 80% capacity factor) Negotiated with provincial grid (above 80% capacity factor)	0.521
Qinshan Phase II, Zhejiang Province	0.414	0.482
Qinshan Phase III, Zhejiang Province	0.471 (to 80% capacity factor)	0.482
Tianwan, Jiangsu Province	0.455	0.455

Source: NDRC (2002); NDRC (2003.1); NDRC (2003.2); China Central Government Website (2007)

Renewable Energy

National energy authorities led by the NDRC and the NEA have striven to strike a balance between incentivizing the development of renewable energy and controlling renewable energy costs. A favored cost control tactic has been to offer concessions for large wind farms and solar power generation bases under competitive bidding procedures, and to use the winning tariff bid as a benchmark for tariffs fixed for other plants.

Incentives to producers have included reduction of VAT and a legal requirement (not always honored) for grid companies to accept renewable (non-hydropower) energy from concentrated generation complexes. To compensate the distribution companies for the higher wholesale costs of renewable electricity and ensure the fulfillment of the renewable energy purchase mandate, the Renewable Energy Law (revised 2010) and a series of central government administrative regulations mandate the collection of a renewable energy surcharge on all electricity sold in China except to agricultural users and to users in Tibet (NDRC, 2006.1).

In principle, this surcharge is meant to cover the differential between renewable electricity and coal-generated power, as well as a portion of investment and maintenance costs for facilities to connect renewable generation plants to the grid that cannot be covered in distribution tariffs. To ensure that distribution companies do not divert the surcharge to other uses, the proceeds are turned over to the Ministry of Finance, and the grid companies are required to apply with supporting documentation to the Ministry and to the NEA for disbursement of the funds (MOF, 2012).

After an adjustment in 2011 (only the second since 2006), this surcharge rose to 0.008 CNY per kWh, yielding approximately 36.5 billion CNY in 2011 to be apportioned among the distribution companies. More timely adjustments in the amount of the surcharge, and somewhat less cumbersome procedures for use of proceeds may be necessary for the surcharge to fully eliminate financial counterincentives to grid company compliance, with the requirement that they purchase all renewable energy that can be generated at approved wholesale tariffs (MOF, 2011).

Wind

From 2007-2009, wholesale tariffs for wind farms were regulated by the provinces, and those farms over 50 MW were regulated by the NDRC according to the results of bids for projects offered for concession. This led to considerable turbulence, with tariffs ranging from as high as 0.7 CNY per kWh for certain small projects to as low as 0.48 CNY per kWh for certain concession projects managed by the NDRC. Some concessionaires walked away from projects because of overly aggressive tariffs, and numerous developers sized their farms at 49.5 MW to avoid regulation by the NDRC. To rectify this situation, the NDRC standardized tariffs for future plants on a regional basis according to the local wind regime in 2009 (**Table 21**). These tariffs ranged from about 25-50 percent higher than those for coal-fired power, not including transmission fees from remote areas, which could add an additional 0.1 CNY per kWh. As of third quarter 2012, when bids for the first offshore wind concessions were being evaluated, wholesale tariffs for offshore wind-farms remained to be determined.

TABLE 21: CHINA WIND ELECTRICITY WHOLESALE TARIFFS, SEPTEMBER 2012

Wind Regime Category	Wholesale Tariff CNY/kWh)	Provinces
Category I	0.51	Western Inner Mongolia Xinjiang: Urumqi, Shihezi, and Karamai Municipalities; Yili Kazakh and Changji Hui Autonomous Prefectures
Category II	0.54	Hebei Province: Zhangjiakou and Chengde Municipalities Northeast Inner Mongolia Gansu Province: Zhangye, Jiuquan, and Jiayuguan Municipalities
Category III	0.58	Jilin Province: SongCNY and Baicheng Municipalities Heilongjiang Province: Jixi, Shuangyashan, Qitaihe, Shuihua, and Yichun Municipalities; Daxinganling Region Gansu Province: all areas not listed in Category II Xinjiang: all areas not listed in Category I Ningxia
Category IV	0.61	All other regions

Source: NDRC (2009.2)

Solar

In August 2011, the NDRC fixed wholesale tariffs for solar photovoltaic power sold to the public grid from new projects at 1.00 CNY per kWh, approximately 120 percent higher than average coal power tariffs (NDRC, 2011.7).

Biomass

Regulations issued in 2006 called for biomass power plant wholesale tariffs to be fixed at 0.25 CNY per kWh higher than the then-prevailing tariff for coal-fired power. At the time, this represented about a 65-75 percent premium; as of 2012, it was closer to a 55-60 percent premium on average (NDRC, 2006.1).

Final End-user Tariffs

The following general principles characterized retail tariffs fixed by NDRC for electricity sold by large provincial public grid companies as of third quarter 2012:

- Residential users, which paid tariffs approximately 15 percent higher than local coal-fired wholesale tariffs, were somewhat subsidized by industrial users, whose tariffs ranged from 30-50 percent higher than the coal-fired wholesale tariffs.
- The largest industrial users paid significantly less than the smaller ones, but were also subject to capacity of approximately 40 CNY per MW for their peak load, and approximately 30 CNY per kilovolt of transformer capacity. As industry accounted for approximately 75 percent of total national electricity consumption, industrial tariffs carried by far the largest weight in the overall structure.
- Tariffs for small and medium-sized fertilizer plants were heavily subsidized.
- Tariffs for commercial users (accounting for approximately three percent of national electricity consumption) were the least favored by a considerable margin, paying in the vicinity of 80-100 percent more than wholesale coal tariffs.

Certain provinces/municipalities such as Shanghai, charge significant premiums for consumption during sharp peak periods, and increase tariffs as residential users consume larger volumes of electricity. But in the majority of cases, the tariffs fixed according to the above principles are uniform. **Table 22** shows the retail tariffs in selected provinces by power consumer.

TABLE 22: RETAIL TARIFFS IN SELECTED PROVINCES
(CNY/KWH-NOT INCLUSIVE OF 0.8 CNY PER KWH RENEWABLE ENERGY SURCHARGE)

	Jiangsu	Anhui	Chongqing	Guizhou
Coal power wholesale tariff	0.455	0.446	0.444	0.373
Residential tariff	0.518-0.528	0.55-0.57	0.510-0.520	0.446-0.456
Large industrial Tariffs	0.604-0.667	0.605-0.675	0.567-0.672	0.495-0.550
Medium fertilizer	0.267-0.297	0.426-0.456	0.435-0.38	0.362-0.407
Commercial and small industry	0.852-0.882	0.864-0.894	0.793-0.848	0.838-0.953
Agriculture	0.484-0.509	0.526 0.556	0.538-0.568	0.455-0.475
Rural villages	0.357-0.363	0.322-0.352	0.306-0.336	0.315-0.325

Source: NDRC (2011.8), NDRC (2011.9)

4.2.4 Power from CMM

The combination of increasingly strong mandates from the Chinese government to utilize rather than waste CMM, with the prospect of significant carbon credit revenue opened up by the implementation of the CDM under the Kyoto Protocol in 2004, resulted in a wave of CMM power projects sponsored by coal mines and Western purchasers/brokers of carbon credits. An aggregate 750 MW of CMM power generation capacity at coal mines around the country came into operation from 2006-2010, including 120 MW at a flagship station in Jincheng, Shanxi Province funded by the Asian Development Bank (NEA, 2011). The great majority of this capacity consisted of 0.5 MW internal combustion engines with approximately 30 percent thermal efficiency made in China. These burn CMM of 20-40 percent methane concentration and are installed in highly distributed fashion adjacent to the vacuum pumping stations which remove the CMM from the various mines.

The various policy pronouncements regarding CMM-generated power have emphasized that given its distributed nature, the primary consumers should be the mines themselves. But documents such as the NDRC's "Opinions Regarding Implementation of the Use of CBM/CMM for Power Generation" of 2007 also make clear that, just as with renewable energy, the public grid companies are obligated to facilitate the interconnection of the CMM power stations to the grid and to purchase any excess power that they generate. The document stipulates that the grid is obligated to pay an off-take price equivalent to that paid for biomass power projects, i.e., the coal power off-take prices in effect in 2006 plus a premium of 0.25 CNY per kWh (NDRC, 2007.4).

A substantial amount of anecdotal evidence suggests that the grid companies have fought with the mining companies over apportionment of interconnection facility investment costs for the often-remote generating sites, and have restricted dispatch in an unpredictable manner even after agreements have been reached and the interconnection facilities constructed. In few cases, the grid companies have offered more than the prevailing off-take tariff for coal-fired power, in part because, unlike power from renewable energy sources, there is no effective nationwide mechanism for passing the 0.25 CNY per kWh premium mandated by the NDRC's 2007 "Opinions" through to the final end-users.

The NEA's Twelfth Five-year Plan for Development of CBM/CMM calls for CMM power generation capacity to quadruple to 2,850 MW between 2010 and 2015, and reiterates that, while the power should be consumed by the mines themselves when possible, the policies regarding off-take by the grid should be implemented. Given the limited ability of the mines to absorb all of the power, the fulfillment of the Twelfth Five-year Plan targets will depend on more rigorous adherence by the grid to the off-take policies (NEA, 2011).

The evolution of policy in Shanxi, for which coal is the mainstay of the provincial economy, demonstrates both the potential and the pitfalls of the off-take policies. Between 2006 and 2011, 26 separate CMM power stations with an aggregate capacity of 381 MW reached interconnection and off-take agreements with the Shanxi Power Grid Company, far more than in any other province. The grid only paid an off-take price of 0.38 CNY per kWh, approximately the same as that for coal power, in contravention of the stipulation that CMM power should be purchased at a 0.25 CNY per kWh premium over 2006 coal power prices.

In January of 2011, after two to three years of negotiations involving the grid company, CMM power plant owners, and the provincial government, the Shanxi Price Bureau issued a notification that the off-take price for all 26 CMM power plants would be increased to 0.509 CNY per kWh, in line with the requirement for the 0.25 CNY per kWh premium. The grid company is to be compensated for its increased wholesale power purchase costs through reallocation of the proceeds of a long-standing 0.0088 CNY per kWh surcharge on power sales in Shanxi that had originally been set aside by the central and provincial governments to fund new power plant construction in the province (Shanxi Price Bureau, 2011).

While the precedent is an encouraging one for the CMM power generators, the length of time required to reach agreement – in a province where the coal mining industry has more political influence than in almost any other – underscores the difficulties of fully implementing the policies regarding CMM power plant off-take, in the absence of dedicated funding to compensate the grid for the extra expense. In practice, policy solutions may have to originate at the provincial level as in Shanxi, rather than at the central level. Not all provinces are likely to have a source of revenue for compensation of the grid company as Shanxi's 0.0088 CNY per kWh surcharge.

4.3 Anhui/East China Grid

4.3.1 Anhui Electricity Supply Demand, Organizational Structure, Dispatch and Pricing

4.3.1.1 Anhui's Power Industry in a Regional Context

The inland province of Anhui and the Yangtze River Delta coastal provinces of Shanghai, Zhejiang, and Jiangsu, which adjoin Anhui to the east, comprise the core of the East China Power Grid (ECPG), subject to the management of the East China Power Grid Company. The Yangtze Delta provinces, which have spearheaded China's growth since the beginning of the reform, but lack conventional energy resources, are enormous load centers which have depended for the most part on power plants burning coal shipped from the north. Anhui, by contrast, has developed more slowly but is well endowed with coal.

It has therefore become government policy to supplement locally generated power with power from coal-fired plants in Anhui. Three 500 and one 1000 kV AC transmission lines now with aggregate capacity of about 15,000 MW now connect Anhui to the Delta provinces. By the end of 2015, 12,000 MW of power generation capacity jointly invested in by government energy companies from the Delta provinces and Anhui coal interests and financed on favorable terms by state banks will be in operation under the "Anhui Electricity to the East" program, with output fully dedicated to the Delta provinces. Since 2009, the Delta provinces have relied on external sources for about 15 percent of their electricity, with Anhui supplying approximately one third (an amount equal to over 20 percent of Anhui's generation), and Three Gorges and other western hydropower plants the remainder (**Table 23**).

TABLE 23: ELECTRICITY GENERATION AND CONSUMPTION IN THE EAST CHINA POWER GRID, 2009-2013 (BILLION KWH, % INCREASE YEAR ON YEAR)

	2009		2010		2011		2012		2013	
Anhui										
Generation	132.1	12.9%	144.4	9.3%	163.5	13.2%	180.1	10.2%	195.8	8.7%
Consumption	95.2	10.9%	107.8	13.2%	122.1	13.3%	136.1	11.5%	152.8	12.3%
Surplus/Deficit	36.9		36.6		41.4		44.0		43.0	
Jiangsu										
Generation	298.3	4.0%	349.9	14.7%	376.3	12.0%	400.1	6.3%	427.2	6.8%
Consumption	331.4	6.3%	386.4	16.6%	428.2	10.8%	458.1	7.0%	495.7	8.2%
Surplus/Deficit	-33.1		-36.5		-51.9		-58.0		-68.5	
Shanghai										
Generation	76.7	0.6%	87.6	12.6%	94.9	8.3%	97.4	2.6%	97.2	-0.2%
Consumption	115.3	1.3%	129.6	12.4%	134.0	3.4%	135.3	1.0%	141.1	4.3%
Surplus/Deficit	-27.7		-42.0		-39.1		-37.9		-43.9	
Zhejiang										
Generation	219.0	17.9%	249.6	14.3%	277.7	8.1%	280.8	1.1%	293.2	4.4%
Consumption	247.1	6.4%	282.1	14.1%	311.7	10.5%	321.1	3.0%	345.3	7.5%
Surplus/Deficit	-28.2		-32.4		-34.0		-40.3		-52.1	
Shanghai, Zhejiang, Jiangsu aggregate										
Generation	594.0	8.3%	687.2	21.1%	748.9	3.9%	778.3	3.9%	817.5	5.0%
Consumption	693.9	5.5%	798.1	15.0%	873.9	9.5%	914.5	4.6%	982.1	7.4%
Surplus/Deficit	-99.9		-111		-125		-136		-164	

Sources: Anhui Statistics Bureau 2014; CESY 2012, p. 44, 97; ChinaPower 2014; Jiangsu Statistical Bureau 2014;NDRC 2014.2; Zhejiang Development and Reform Commission 2014; Zhejiang Statistical Bureau 2014

4.3.1.2 Anhui's Future in the East China Region

While growth in electricity consumption in the three Delta provinces has moderated relative to the double digit rates of the first decade of the 21st century, they have remained strong relative to other rich areas, particularly in Jiangsu. The largest of the three provinces maintained seven to eight percent growth rates in both 2012 and 2013. This growth occurred even as the national economy slowed down with the unwinding of the domestic economic stimulus program and government moves to tighten real estate credit. After a down year in 2012, Zhejiang's electricity consumption rebounded to the level of Jiangsu. Both provinces saw double digit growth rates in the residential and service sectors. Only Shanghai, with a narrower economic base and a more heavily urbanized population, showed signs of entering into a longer-term growth slump with regard to electricity consumption.

As **Table 23** shows, since 2011, growth in power generation in Jiangsu and Zhejiang has not kept pace with the growth rate in consumption. This may be temporarily reversed for a year or two, as Zhejiang will be bringing almost 7500 MW of base-loaded coal fired capacity online, about 15 percent of which was already in operation in 2013. Jiangsu will add at least 5200 MW of large unit coal-fired capacity by the middle of 2015, on top of 5600 MW added in 2013, an amount also equal to about 15 percent of the previous coal capacity.

The government-owned companies in Jiangsu and Zhejiang have also made their first major investments in natural gas combined cycle power plants in almost a decade, with Zhejiang bringing on close to 6000 MW in 2013-2014, and Jiangsu planning a comparable scale investment over a somewhat more extended period of time. Environmental as much as power supply considerations are driving the combined cycle plants, many of which are designed to replace coal-fired combined heat and power (CHP) plants in major cities. Jiangsu and Zhejiang are also moving as aggressively as they can to develop renewable energy, including offshore wind and photovoltaic plants (Beijixing, 2014).

Ultimately, a combination of environmental and economic considerations make it most unlikely that electricity supply in the Delta provinces will be able to keep up with a pace of electricity consumption growth anywhere close to the 2013 level of 7.5 percent. A landmark air quality action plan promulgated by the Central government's State Council in September 2013 called for coal consumption in the Yangtze Delta to begin to decline by 2017, and forbids the construction of any new greenfield plants[1] other than CHP plants. Additions to existing coal-fired plants are permitted, but only under conditions where sufficient capacity (in plants with aggregate capacity of over 300 MW) is shut down to ensure that the new plants represent no net increase in coal consumption (China State Council, 2013).

With imported LNG gas running as high as four CNY per cubic meter in the Yangtze Delta and new pipeline gas at 3.32 CNY per cubic meter under the natural gas price reforms of 2013, the cost of gas-fired power in new combined cycle plants has been estimated at 0.65-0.8 CNY per kWh in Jiangsu and Zhejiang (China Electricity Council, 2013). Offtake prices for coal power are approximately 0.45 CNY per kWh (inclusive of surcharges to cover sulfur oxides, nitrogen oxides, and fine particulate removal) and electricity end-use tariffs are pegged primarily to coal power. The State Council's Air Quality Action reiterated, furthermore, that direct burning of natural gas in households and factories remains the favored use for the fuel, and that base loading natural gas plants should in principle be prohibited. Outside of the Delta provinces in Beijing, however, coal-fired power plants are being replaced by gas-fired plants in order to meet air quality targets. The first of four major coal-fired power plants was closed in July of 2014 with the remaining three to be closed by the end of 2016. Four gas-fired power plants are being built in order to reach 2016 air pollution reduction targets of cutting 10,000 tonnes of sulfur dioxide, 19,000 tonnes of nitric oxide, and 3,000 tonnes of dust annually (China Daily, 2014.1).

Under the State Council requirements and gas price environment, the most politically and economically palatable option for Jiangsu and Zhejiang political leaders to ensure power supply will likely be to import a greater share of electricity from outside provinces, whether from hydropower plants in the far west, or coal fired plants in interior provinces such as Anhui which are not covered by the Air Quality Action Plan. Planning for +/-800 KV HVDC transmission line connecting coal and wind-rich Inner Mongolia to Jiangsu appeared to be moving towards government approval in 2014, and Zhejiang provincially-owned power generation companies announced agreements to build a series of new coal-fired power plants in Ningxia Province in the distant northwest to be shipped to Zhejiang through a similar line. In principle, there should be a market in the Delta provinces for significantly increased volumes of coal or other power from nearby Anhui, whose grid is already substantially integrated with those in the Delta provinces (Caijing Daily, 2013.1; Twenty-First Century Economic Report, 2013).

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[1] project that lacks any constraints imposed by prior work

4.3.2 Electricity Supply and Demand in Anhui and Potential for Power Generated from CMM

4.3.2.1 Demand

Since 2009, Anhui has exemplified the rapidly increasing role of China's interior provinces in the country's overall economy. Anhui's GDP growth has consistently outpaced the country as a whole by about three to 4.5 percentage points, remaining in double digits even as the national rate decreased to 7.7 percent in 2012-2013 (**Table 24**). Manufacturing, utilities and construction, which account for over 50 percent of the provincial economy, have been consistently strong, growing by margins of 16.8-20.7 percent 2009-2011, and by 14.4 and 12.4 percent, respectively, in 2012 and 2013; a sign that industry is migrating to Anhui from the adjacent coastal regions.

TABLE 24: ANHUI GDP GROWTH AND ELECTRICITY CONSUMPTION (PERCENT)

Anhui					
• **Economic growth**	12.9%	14.5%	13.5	12.1	10.4%
• **Electricity consumption growth**	10.9%	13.2%	13.3%	11.5%	12.3%
China					
• **Economic growth**	9.2%	10.4%	9.2%	7.7%	7.7%
• **Electricity consumption growth**	7.2%	13.2%	11.9%	5.5%	7.5%

Sources: Anhui Statistics Bureau 2010, 2011, 2012, 2013, 2014; CESY 2013, p. 87; NBSC 2010, 2011, 2012, 2013, 2014; NBSC 2010, 2011, 2012, 2013, 2014; NDRC 2014.2; NEA 2014

Not surprisingly, Anhui provincial electricity consumption has likewise continued to grow at double digit rates. In 2013, manufacturing/mining/construction, services, and residential electricity usage rose by 11.3 percent, 16.5 percent, and 13.8 percent, respectively (**Figure 23**).

Although it remains to be seen how long the pace of industrial growth can be maintained at the levels of recent years, there is reason to assume that it will remain above the national average given Anhui's status as the inland province closest to the Yangtze Delta, the convenience of its communications and transportation to the delta, its large population (69 million), and its below-average rate of urbanization (47.9 percent) per capita GDP (27,500 CNY, or about $4500). Electricity consumption increase of nine to 10 percent per year is a reasonably conservative projection for the medium-term.

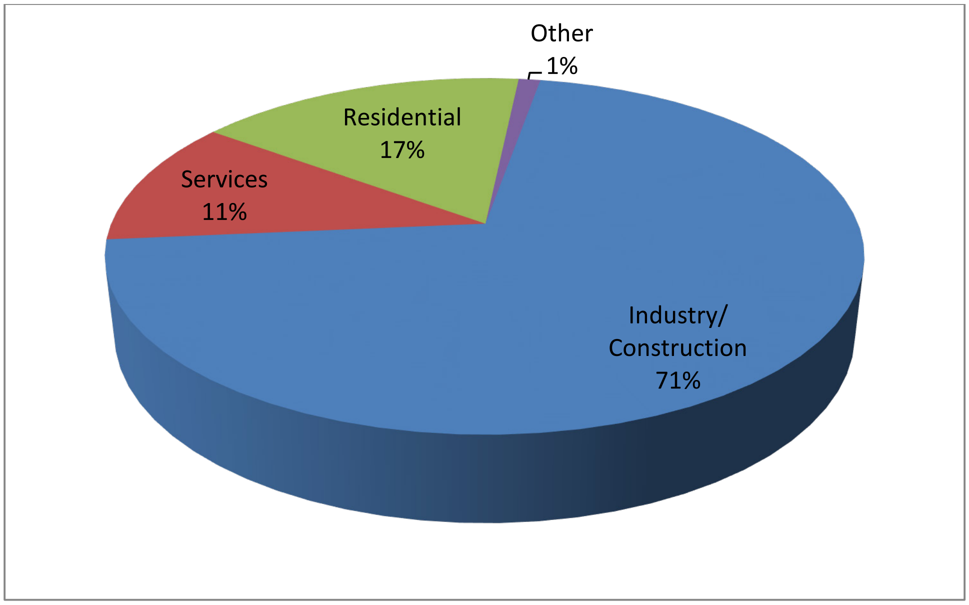

FIGURE 23: ANHUI ELECTRICITY CONSUMPTION BY SECTOR, 2013
Source: NDRC 2014.2

Coal-fired power plants account for over almost 90 percent of the province's 39,000 MW, and for over 95 percent of its generation. New capacity has been added at a steady pace of about 3000 MW per year since about 2005, but as can be seen in **Table 25** both overall generation and coal fired base-loaded capacity has increased at slower rate than consumption in Anhui in three of the four years 2010-2013, costing Anhui power providers sales in the Yangtze delta.

Five coal-fired plants with aggregate capacity of almost 8000 MW in units of 660 and 1000 MW are likely to be onstream in 2014-2016, with output from 4600 MW of this capacity to be dedicated to the delta and the remainder for the Anhui grid. An additional 6600 MW, most of which would be dispatched by the Anhui grid were in relatively advanced state of permitting.

TABLE 25: ANHUI POWER BALANCES, 2010-2013

Consumption (billion kWh)	107.8	13.2%	122.1	13.3%	136.1	11.5%	152.8	12.3%
Generation (billion kWh)	144.4	9.3%	163.5	13.2%	180.1	10.2%	195.8	8.7%
-Thermal	142.0	NA	161.0	NA	174.4	NA	NA	NA
Generation Capacity (MW)	29,330	NA	31,790	8.4%	35,300	11.0%	39,331	11.4%
-Thermal	27,630	NA	29,590	NA	32,200	NA	35,967	11.7%
-Wind	NA	NA	NA	NA	300	NA	492	NA

Sources: Anhui Development and Reform Commission 2013; CEPY pp 630-631; CESY 2013 Tables 3-9, 3-10, 3-11, 4-23; Securities Times 2014

Although Anhui is not covered by the same restrictions on construction of new coal fired power plants as are the Yangtze Delta Provinces, and because of the complex and lengthy nature of the coal-fired power plant permitting process, the rapid growth of demand, and pressures for cleaner power, the Anhui grid should begin to consider alternatives to coal.

The Anhui provincial leadership called for wider use of CMM in its energy five-year plan for 2011-2015, but without specific reference to the power sector. Possibly the growing attention to distributed power will raise CMM's profile. From a supply and demand perspective, Anhui needs any power that CMM plants could provide.

4.3.3 Pricing

4.3.3.1 Wholesale

As of the beginning of 2014, wholesale prices paid by the Anhui grid and the East China grid (for the "Anhui Electricity to the East" plants directly dispatched to the Yangtze Delta provinces) are as follows in **Table 26.**

TABLE 26: POWER WHOLESALE PRICES IN ANHUI (CNY PER KWH)

Coal-fired power plants[2]	0.4211
Small hydropower	0.338
Wind	0.61
Biomass	0.75

Source: Anhui Development and Reform Commission 2013

National regulations published in 2007 call for CMM power to be purchased by the grid at the same level as biomass.

4.3.3.2 End-user Tariffs

As of the beginning of 2014, the standard retail tariff schedule in Anhui is as follows in **Table 27**. It can be seen that residential customers are subsidized by industrial and commercial customers to a significant extent, that power to large industrial customers is significantly discounted relative to smaller ones, that the most electricity intensive industries are given a slight discount relative to other large industrial customers, and that medium and small fertilizer plants are sold power at close to wholesale costs.

[2] Coal-fired power plant prices are inclusive of a 0.015 CNY per kWh surcharge for flue gas desulfurization, which is nearly universal in Anhui, but not of 0.008 CNY per kWh surcharge for SCR or SNCR nitrogen oxide mitigation facilities which are gradually being introduced.

TABLE 27: STANDARD END-USER ELECTRICITY TARIFFS IN ANHUI, EARLY 2014

	Usage Fees (CNY/WH					Capacity Fees	
	<1KV	1-10 KV	35 KV	110 KV	220 kV	CNY/KW/ Month	CNY/KVA/ Month
Residential	0.5653	0.5503	NA	NA	NA	NA	NA
Ordinary industry and commerce	0.8938	0.8788	0.8638	NA	NA	NA	NA
Large industry	NA	0.675	0.66	0.645	0.635	40	30
Electrolytic aluminum, synthetic ammonia, caustic, soda, etc.	NA	0.665	0.65	0.635	0.625	40	30
Medium-small fertilizer plants	NA	0.4563	0.4413	0.4263	NA	21	15
Agriculture	0.5558	0.5408	0.5258	NA	NA	NA	NA
Rural villages	0.3516	0.3366	0.3216	NA	NA	NA	NA

Source: Anhui Price Bureau Power Price Sales Table

Like many other provinces, Anhui implements a peak pricing system for most customers, with peak prices fixed at 50 percent higher than standard prices (60 percent during the summer peak months of July-September), and off-peak night prices fixed approximately 38 percent lower than standard prices. For coal mines, which would be classified as "large industry", the prices (CNY/kWh) are summarized in **Table 28**.

TABLE 28: ANHUI LARGE INDUSTRIAL END-USER TARIFFS, PEAK AND OFF PEAK (CNY/KWH)

	<1KV	1-10 KV	35 KV	110 KV
Summer peak : 8-9 AM, 11 AM-6 PM	1.0623	1.0376	1.0128	0.9963
Non-summer peak	1.0012	0.978	0.9547	0.9392
Standard: 8-9 AM, 11AM-6:00 PM	0.665	0.65	0.635	0.625
Night off-peak: 11 PM-8 AM	0.4144	0.4055	0.3967	0.3908

Source: Anhui Price Bureau Power Price Sales Table

4.4 Chongqing and Hebi/Central China Grid

4.4.1 Central China Electricity Grid

The Central China Electricity Grid under the SGCC controls the provincial grid companies of Henan, Hubei, Hunan, Jiangxi, Sichuan and Chongqing, and the transfer of electricity between these provinces (**Figure 24**). In aggregate, the six provinces accounted for 19.0 and 18.5 percent, respectively, of China's 2011 electricity production and consumption. Henan, with the largest economy of the region, accounted for approximately 30 percent of both production and consumption in 2011. Regional growth rates for electricity generation and consumption averaged 15.8 and 26.1 percent, respectively, from 2010-2012.

Within the region, Hubei has run a large and Sichuan a small power surplus, while the other provinces within the grid area have consumed more than they produce to varying degrees (**Table 29**). The Sichuan and Hubei surpluses have been based on their rich hydropower resources; approximately 55 percent of Hubei's 2011 electricity generation was hydropower, primarily from the massive Three Gorges complex, while over two thirds of Sichuan's generation came from hydropower stations, led by the Ertan plant on the Yalong River. Generation in the other provinces is dominated by coal-fired power, with the 2011 coal-fired power generation percentage ranging from 72 percent in Chongqing to 94 percent in Henan.

TABLE 29: CENTRAL CHINA POWER GRID PRODUCTION AND CONSUMPTION (GWH)

	2006	2007	2008	2009	2010	2011	2012
Electricity Production, Total (GWh)	561,000	650,600	714,969	748,757	842,400	98,800	975,600
Electricity Consumption, Total	525,930	603,600	NA	NA	773,200	867,300	975,200
Chongqing Production	29,130	37,455	45,725	47,432	50,400	58,200	59,800
Chongqing Consumption	40,500	44,900	48,600	53,200	62,500	71,700	72,300
Hunan Production	75,490	86,015	92,725	102,795	122,600	134,700	139,800
Hunan Consumption	91,300	102,000	NA	NA	117,200	154,500	158,200
Henan Production	160,050	191,826	197,778	205,546	219,200	258,500	264,300
Henan Consumption	153,400	186,400	209,300	227,500	246,400	282,300	292,600
Jiangxi Production	43,990	50,201	57,600	53,300	66,400	73,000	72,800
Jiangxi Consumption	45,300	51,600	54,700	60,900	70,100	83,500	86,800
Hubei Production	130,667	158,839	182,844	181,806	204,300	208,600	223,800
Hubei Consumption	89,500	100,900	107,600	118,300	141,800	157,300	164,300
Sichuan Production	122,658	126,292	138,297	157,878	179,500	198,100	215,100
Sichuan Consumption	105,900	117,800	121,300	136,200	154,900	196,300	201,000
Generating Capacity (MW)	129,200	NA	NA	NA	NA	NA	NA

Source: CESY (2013) p. 44, 97; CESY (2011), p.43, 117; HSB (2011, 2012); NBSC (2007), CEPY (2007), p.625; State Energy Regulatory Commission 2012

Note: There are discrepancies between sources for Hunan's consumption in 2008-2009.

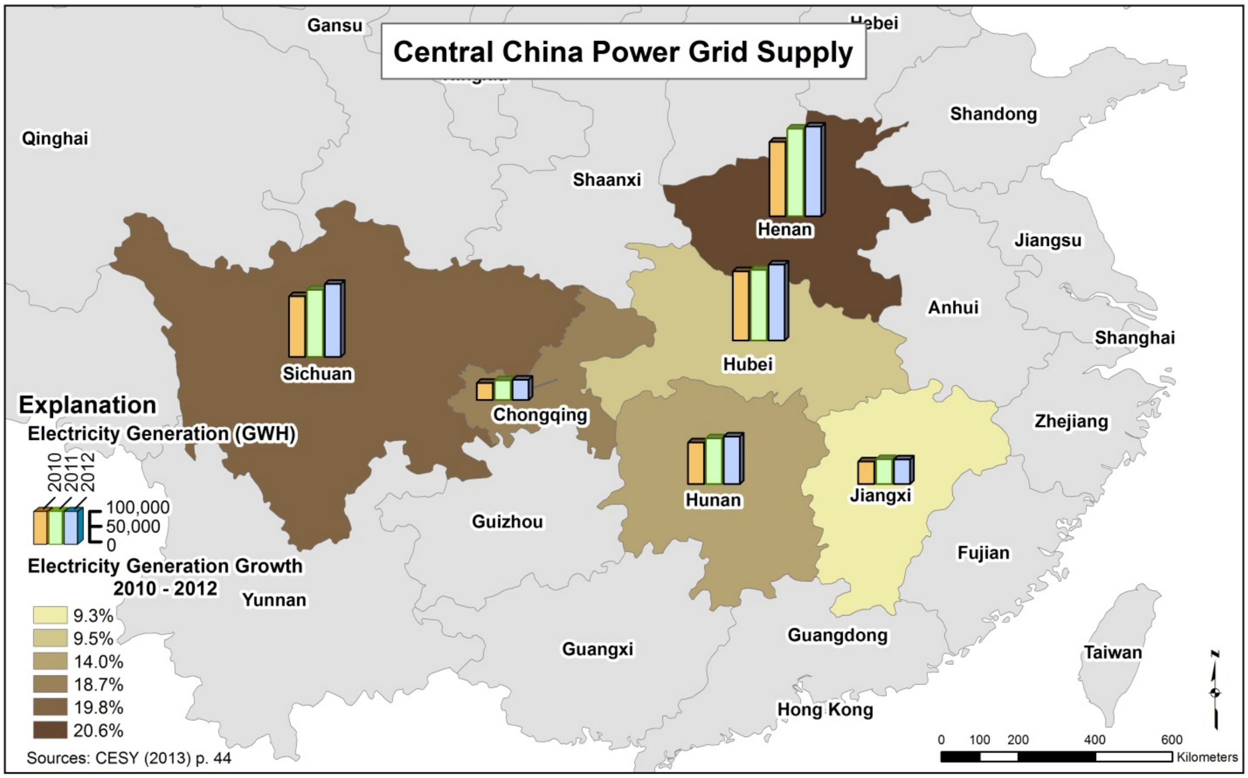

FIGURE 24: CENTRAL CHINA POWER GRID SUPPLY

Source: CESY 2013 p. 44

The Central China grid as a whole runs a small surplus with the rest of China, consisting primarily of shipments from Three Gorges to the eastern Yangtze Valley provinces along dedicated 500 kV transmission lines. The nation's first 1000 kV AC transmission line, completed in 2010, links Southeast Shanxi Province in the North China power grid to Jingmen, Hubei Province in the Central China grid. This allows for shipment of as much as 4,000 MW of coal-fired power from Shanxi to Central China in low water season, and shipment of hydroelectricity from Central China to North China in high water season.

Interconnection and integration with other trans-provincial grids will increase during the Twelfth Five-year Plan. Zhengzhou, the capital of Henan, will be the terminus of a +/-800 kV DC transmission line originating in Hami, Xinjiang which will serve primarily to transmit electricity from new wind and coal-fired plants in Xinjiang to the heartland. Power from massive new hydropower plants on the Upper Yangtze and its tributaries in Sichuan Province due to come onstream during 2011-2015 or soon after, such as Xiangjiaba (6,400 MW), Jinping Phases I and II (8,400 MW), Xiluodu (12,600 MW), and Guandi (2400 MW), will be transmitted to the East China region through new high capacity lines. A +/- 800 kV line from Xiangjiaba to Shanghai has been completed, and +/-800 kV lines from Xiluodu to Zhejiang and from Jinping to Jiangsu were under construction in 2012. Shorter distance, lower capacity lines from neighboring regions to the north where, in contrast to the Central China Grid region, coal resources are plentiful, will also supply power to areas such as Chongqing by 2015.

The Sichuan hydropower plants represent by far the most significant power generation investments that will take place in the Central China Grid region itself from 2010-2015. The Hunan and Henan provincial governments have put forward plans calling for generation capacity to increase at a 7-7.5 percent per year rate during the period, based primarily on the addition of new coal-fired capacity (**Table 30**) and Chongqing government officials hope to double the municipality's capacity. As of third quarter 2012, however, the NDRC has not approved the construction of new projects at a sufficient pace to ensure fulfillment of these goals. Of the three provinces, Henan has the best coal resource endowment for large-scale thermal power expansion. But even Henan will likely depend at least in part on coal from Shanxi, Inner Mongolia, and Shaanxi to meet its self-proclaimed targets. Northern coal shipments are likely to depend on the timely construction of new transport infrastructure such as the proposed rail line from Ordos in Inner Mongolia through Hubei to Hunan and Jiangxi (see Inner Mongolia coal section).

The provincial governments in all of the central power grid provinces are promoting the development of local (non-hydropower) renewable energy vigorously. But conditions will likely only allow for small-scale distributed wind and biomass power plants. In sum, energy imports, whether in the form of fuel, power transmitted through long-distance lines, or both, will become an increasingly critical feature of electricity economics in the central grid region.

TABLE 30: POWER GENERATION CAPACITY IN THE CENTRAL CHINA REGION (MW)

Henan	51,000	72,000
-Thermal	45,000	64,000
-Hydro	6,000	NA
Hunan	28,000 (2010)	41,000
-Thermal	14,000	24,000
-Hydro	14,000	16,000
Chongqing	10,000 (2010)	20,000
-Thermal	6,100 (est)	NA
-Hydro	3,900 (est)	NA
Sichuan	51,000 (2011)	88,000
-Thermal	25,000	33,000
-Hydro	25,000	55,000
Hubei	53,000	NA
-Thermal	19,000	NA
-Hydro	34,000	NA

Source: Henan Provincial Government (2012); Beijixing (2012); Hunan Provincial Government (2012); Chongqing Fengjie County Government (2011); Hubei Electric Power (2011)

4.4.2 Chongqing Electricity Supply, Demand, Organizational Structure, Dispatch and Pricing

Power consumption in Chongqing (including both centrally dispatched power from the Chongqing Power Grid Company and the approximately 10-15 percent coming from several smaller local grids) grew at an average of 10.8 percent per year rate from 2006-2012 to a level of 72,300 GWh. Industry has been the primary driver of growth in power use, accounting for 58 percent of the total. But the residential and commercial sectors account for a somewhat larger share than in the country as a whole, a reflection of the contribution of the jump in the urbanization ratio from 45 percent to 55 percent over the period, the fastest of all of China's centrally controlled administrative units. (**Table 31**, **Figure 25**).

Chongqing's economic and electricity consumption growth slowed down sharply in the first half of 2012 due the nationwide slump in real estate and the European recession. After these short term factors have passed, electricity consumption growth rates are likely to fall from 2006-2012 levels as the national economy reorients towards consumption. But growth could still average as much as 8-10 percent, higher than the rest of China, due to the momentum of urbanization.

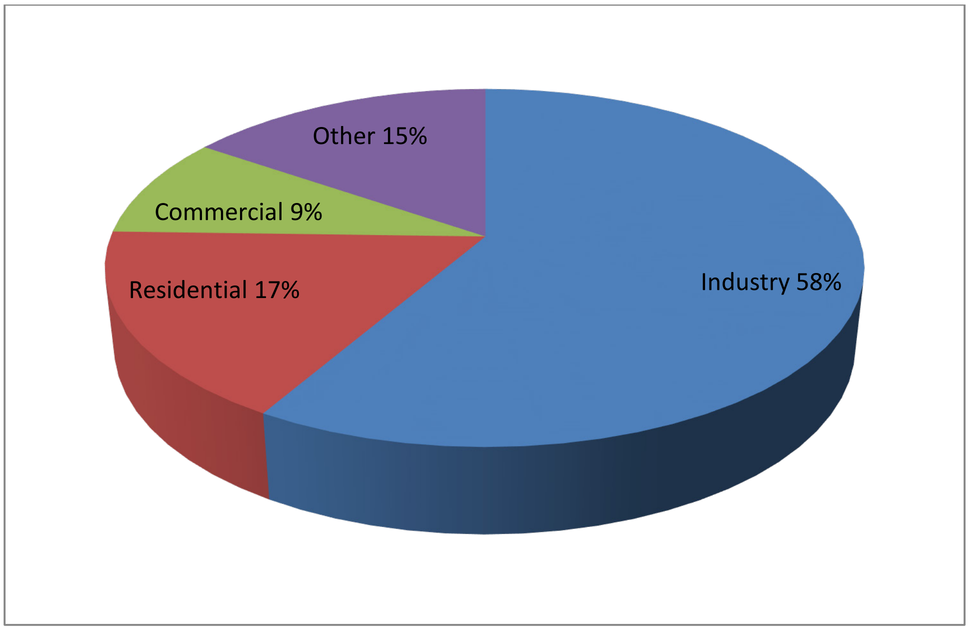

FIGURE 25: CHONGQING POWER CONSUMPTION BY SECTOR, 2012
CESY (2013) p. 263

TABLE 31: CHONGQING POWER SUPPLY AND DEMAND

	2006	2007	2008	2009	2010	2011	2012
Electricity Consumption (GWh)	40,131	44,921	48,592	53,234	62,600	71,700	72,300
(+Growth)	(+14.1%)	(+11.4%)	(+8.2%)	(+9.6%)	(+17.6%)	(+14.5%)	(+0.01%)
Electricity Generation (GWh)	28,862	37,455	45,725	47,432	50,400	58,200	59,800
(+Growth)	(+13.6%)	(+30.0%)	(22.1%)	(+3.7%)	(+6.3%)	(+15.5%)	(+2.7%)
-Thermal	23,487	29,069	28,488	30,759	33,376	39,350	33,880
-Hydro	5,643	8,375	17,161	16,574	16,925	18,427	24,475
Generating Capacity (MW)	7,597	NA	NA	NA	10,000	NA	NA

Centrally dispatched	NA	8,000	8,639	NA	NA	NA	NA

Source: CESY (2013) p. 45, 46, 97; Chongqing Energy Investment Corporation private communication, CQPC (2008.1, 2008.2), CESY (2008), pp. 43-117; CESY (2010), pp. 44-45, 91; Chongqing News Net (2012)

Despite an aggressive investment program by the Chongqing Municipal government and the five national generating companies in the 2006-2012 period which nearly doubled generating capacity and led to 13 percent per year growth in municipal power generation, Chongqing continued to depend on outside generation sources for 25 percent of its power supply. Two thirds or more of the municipality's own generation has originated from thermal power plants in most years compared to weather/water level-dependent hydropower plants, which actually account for 40 percent of generating capacity. By contrast, the bulk of the electricity sent to Chongqing from neighboring provinces through the Central China Grid Company is relatively inexpensive hydropower from the mega Three Gorges project, the Ertan station in Sichuan Provinces, and other sources.

The Chongqing Municipal government has put forward a plan to double generating capacity within the city to 20,000 MW or more during the Twelfth Five-year Plan period (Chongqing Fengjie County Government). About 7000 MW of coal-fired power plant capacity have been proposed by the major power generation companies (including four 1000 MW-sized units), but the central government has been slow to approve them. Only 1300 MW in two projects were under construction in 2012, and it was unclear which of the others would ultimately be permitted.

The national government approved the Xiaonanhai 1000 MW hydropower project not far from the city center as part of the Three Gorges Company's program to regulate the Upper Yangtze River, but this project will not produce power until 2017-2018. In the meanwhile, government and private investors have been moving ahead with a series of smaller plants for which central approval is either not required or is easier to obtain, including:

- A series of hydropower plants (100-600 MW range), wind power and biomass power plants totaling approximately 1500 MW capacity; and
- A series of combined heat and power plants burning coal from the smaller local mines totaling about 1000 MW.

The total capacity of all the plants likely to come onstream during the Twelfth Five-year Plan (including 1100 MW of hydropower already commissioned in 2011-2012, and a proposed 700 MW natural gas project) is only about 5000-6000 MW, which most likely will mean a greater reliance on outside power. Only 25 percent of this capacity (the two coal-fired plants) can provide base-loaded power.

The slowdown in Chongqing base load power construction reflects larger power sector macroeconomic issues, in particular limited coal resources in Chongqing. One possible solution is the construction of new transportation facilities to bring in coal from Shaanxi or other northern provinces by some combination of rail and ship. The two proposed projects with 1000 MW generating units are designed for northern coal.

Large scale importation of power, as opposed to or in addition to coal from the north, is another possibility. The State Power Grid Corporation has aggressively promoted this option as part of its plan to build a network of 1000 kV UHV transmission lines to link up the North China, East China, and Central

China regional grids. The central government seemed to be moving in 2012 towards approving at least part of this program, but was still analyzing its economic and technical viability.

Chongqing is pursuing a more modest regional solution by contracting directly with plants in neighboring provinces that have richer coal resources and are not part of the Central China grid. In 2012, construction began on a 1200 MW coal-fired plant in Guizhou Province to the immediate south (China Southern Grid), whose output will be dedicated in its entirety to Chongqing. Chongqing interests were also in advanced discussions to invest in and purchase the output of a proposed 2000 MW coal-fired plant in Ankang, Shaanxi Province to the north (Northwest China grid). These plants, which would transmit power to Chongqing through 500 kV lines, would go some distance to helping Chongqing meet its target for increasing its effective capacity by 10,000 MW during the Twelfth Five-year Plan.

A large-scale nuclear project has also been proposed for Chongqing. But the Japan Fukushima earthquake disaster has clearly given the central authorities pause given Chongqing's proximity to a tectonically active zone.

For the immediate future, the municipality will continue to rely on the hydropower resources from neighboring provinces to fill the growing gap between generation and consumption. A combination of all the options discussed above: hydropower from the major Yangtze River stations, including the Xiaonanhai station in Chongqing itself; thermal electricity from the north through regional grid integration; and local thermal generation using a combination of imported and local coal, supplemented by gas-fired power is the likely outcome for the long term.

The extent of power shortages, and the speed of the recovery from the slowdown in demand in first-half of 2012 will be a precipitating factor for decisions on longer-term development. The more acute the shortages, the stronger will be the pressure for increased generation from plants within Chongqing.

4.4.2.1 Chongqing Power Pricing

Chongqing's price incentives to use hydropower relative to thermal power are clear from **Table 32**. Natural gas power plants and non-hydropower renewable plants receive the highest prices from the grid.

TABLE 32: ELECTRICITY WHOLESALE PRICES TO CHONGQING

Three Gorges Hydro:	0.291 CNY per kWh (delivered to Chongqing)
Ertan Hydro:	0.278 CNY per kWh (delivered to Chongqing)
Hydropower generated in Chongqing	0.32-0.33 CNY per kWh
Local Coal-fired (includes flue gas desulfurization)	0.449 CNY per kWh (new plants with flue gas desulfurization) Existing plants vary
Natural Gas-fired (Henan Province)	0.5534 CNY per kWh (to grid)
Wind	0.61 CNY per kWh
New Biomass	0.65 CNY per kWh

Source: NDRC (2008.2); NDRC (2008.3); NDRC (2011.3)

Retail electricity prices for 2011 are shown in **Table 33**.

TABLE 33: RETAIL ELECTRICITY PRICES, YEAR-END 2011

Residential	0.51-0.52 CNY/kWh
Commercial and small-scale industry	0.793-0.848 CNY/kWh
Large-scale industry:	0.577-0.627 CNY/kWh plus 40 CNY per kW and 26 CNY per kV per month
Coal mines	0.589 CNY/kWh
Chemical fertilizer	0.345-0.492 CNY/kWh
Agriculture	0.538- 0.568 CNY/kWh

Source: CDRC (2011)

4.4.3 Henan Province Electricity Market

Henan, located in North-Central China, is one of China's most populous provinces, with 94 million people counted in the 2010 census. Like most of China's interior provinces, its per capita income (estimated 13,000 CNY in 2012) and urbanization rate (reported 42 percent in 2012) have lagged behind the more developed coastal provinces, its GDP and electricity consumption growth rate kept up with the double digit national average in the first decade of the 21st century. Growth exceeded the national average in 2010 and 2011 as the focus of growth shifted towards interior provinces and the government loosened lending for capital projects to stimulate the economy and counteract the impact of the global economic downturn (**Table 34**).

In 2012-2013, however, national GDP growth dropped from about 10 percent to 7.7 percent in response to the winding down of China's post-global downturn stimulus. Under these new circumstances, Henan's electricity consumption growth rate fell precipitously to 3.3 percent in 2012, and increased only modestly to 5.5 percent in 2013, a full two percentage points lower than the national average for both years (**Table 34**).

TABLE 34: HENAN PROVINCE: GDP AND ELECTRICITY CONSUMPTION GROWTH, 2000-2013

	2000-2008	2009	2010	2011	2012	2013
China National GDP Growth	10.6%	9.2%	10.4%	9.2%	7.7%	7.7%
China National Electricity Consumption						
a. billion kWh	NA	37,032	41,934	46,928	49,591	5,322.3
b. % growth	14.9%	7.2%	13.2%	11.9%	5.5%	7.5%
Henan GDP Growth	NA	10.7%	12.2%	11.6%	10.1%	9.0%
Henan Electricity Consumption						
a. billion kWh	NA	208.1	35.4	266.0	274.8	290.0
b. Growth	14.3%	5.6%	13.1%	13.0%	3.3%	5.5%

Sources: CESY 2013, p. 87; HSB 2010, 2011, 2012, 2013, 2014; NBSC 2010, 2011, 2012, 2013, 2014; NBSC 2010, 2011, 2012, 2013, 2014; NEA 2014

Weak electricity demand in Henan from 2012-2013 resulted directly from the weaknesses of its heavy industry, and particularly its aluminum sector. Like the rest of China, heavy industry has accounted for over two thirds of electricity consumed in Henan (**Figure 26**), however it is the only province where aluminum been as central a driver of the electricity industry. In 2011, Henan smelters produced 3.9 million tonnes of electrolytic aluminum (22 percent of the national total, more than any other province), and purchased one out of every five kilowatt hours of electricity sold in the province.

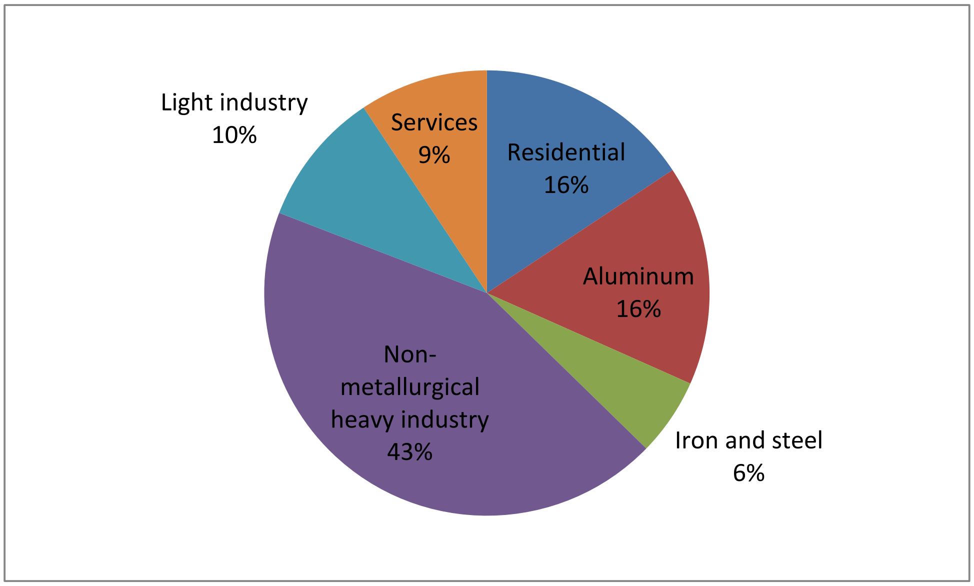

FIGURE 26: HENAN ELECTRICITY CONSUMPTION BY SECTOR, 2013
Source: Henan Electricity Supervision Office 2013

By 2012-2013, the full impact of an investment boom in smelters across China and particularly in western localities such as Xinjiang became apparent, as capacity ballooned to 32 million tonnes per year, while demand, even with a growth rate of 9-9.5 percent over the two years, only reached about 22 million tonnes. As utilization capacity nationwide dropped to about 70 percent and prices plummeted, Henan's smelters proved ill-equipped to compete due in significant measure to the high cost of local coal-fired electricity, which accounts for over 40 percent of the cost of electrolytic aluminum. Three of the province's 12 smelters were reported to have shut down and the others operated well below capacity, as Henan aluminum production dropped by over 5 percent in 2012 and 10 percent in 2013. Given that 10 million tonnes of additional capacity were reported to be under construction nationally as of year-end 2013, it was not clear that the outflow was over (Economic View Net, 2013; HSB 2013, 2014; People's Daily Net, 2013; Yangtze River Nonferrous Net, 2013). A similar situation occurred in the Henan steel industry, which accounts for about 6 percent of the province's electricity consumption as provincial production fell 7.5 percent in 2012 under conditions of substantial national overcapacity. Production decline in the coal industry also negatively impacted electricity consumption starting from 2011 (HSB, 2013).

The Henan Electricity Supervision Office under the NEA projected that demand for electricity in the province would grow by 6 percent in 2014, only slightly higher than the 5.5 percent level of 2013. Quite possibly electricity growth rates near 6-7 percent will become the new normal in Henan, assuming that national GDP growth remains in the 7-8 percent range projected both by the Chinese government and outside observers such as the IMF. Under this scenario, service sector and household consumption of electricity will almost certainly continue to grow at double digit rates, with growth in industrial consumption lagging behind to an extent depending on whether and to what extent aluminum production in the province begins to recover (Henan Electricity Supervision Office, 2014).

4.4.3.1 Electricity Supply

After two years during which electricity consumption in Henan exceeded in-province generation by small but growing margins, consumption and generation moved towards parity in 2013 as generation rose by 10 percent and consumption stagnated (**Table 35**). According to the Henan Electricity Supervision Commission, only in a small number of areas with underdeveloped grids such as Zhoukou in the southwest part of the province was electricity supply noticeably deficient outside of the winter and summer peaks.

TABLE 35: HENAN ELECTRICITY CONSUMPTION BY SECTOR 2011-2013

	2011	2012	2013
Total	2,659.20	2,747.75	2,899.18
Industry	2,041.23	2,040.20	2,100.47
-Heavy Industry	NA	1,795.11	1,825.90
**** Aluminum***	539	501.07	447.61
**** Iron and Steel***	NA	158.44	157.98
**** Cement***	NA	70.04	67.24
-Light Industry	NA	245.10	274.57
Residential	314.6	378.1	439.42
Service Sector	201.64	233.82	261.57
Other	NA	95.63	97.72

Sources: CESY 2013, p. 227; Henan Electricity Supervision Office 2013, 2014

The overwhelming majority of the power generated in Henan is consumed in-province as shown in **Table 36**. Modest amounts of Henan coal-fired power are dispatched through the central China power grid under the State Power Grid Corporation of China to neighboring central China provinces during low water season, while Henan has, through 2013, imported the balance of what it does not generate locally from hydropower plants in other Central China provinces, principally the mega-Three Gorges project in Hubei Province.

TABLE 36: ELECTRICITY BALANCES IN HENAN

	2008	2009	2010	2011	2012	2013
Consumption (billion kWh)	NA	208.1	235.4	266.0	274.8	290.0
Growth	NA	5.6%	13.1%	13.0%	3.3%	5.5%
Generation (billion kWh)	195.3	206.8	228.4	259.5	259.7	281.1
Growth	NA	5.9%	10.4%	13.6%	0.1%	8.2%

	2008	2009	2010	2011	2012	2013
- Hydro (billion kWh) **- Thermal (billion kWh)** **- Renewable (billion kWh)**	9.9 175.5 NA	9.3 195.3 NA	9.2 209.2 NA	9.8 241.5 1.6	12.8 244.9 1.9	11.5 267.2 2.4
Generating Capacity, year-end (MW) **Growth**	NA NA	NA NA	50,600 NA	53,242 5.2%	57,647 8.3%	60,518 5.0%
Maximum Load (MW)	NA	NA	NA	41,820	44,430	48,010

Source: CESY 2013, Tables 3-9, 3-10, 3-11, 4-23; CEPY 2012 pp. 630-631

Thermal power plants account for approximately 90 percent of Henan's power generation capacity, and 95 percent of actual power generated. Almost all of this thermal power comes from approximately 50 coal-fired plants located at mine mouths and large load centers owned by the five national generation companies as well as a variety of other local and national investors, including a number of aluminum companies who generate for their own use. The province's two natural gas combined cycle plants, which are used primarily for peaking purposes, only accounted for about two percent of provincial capacity and generation in 2013 (**Table 37**).

TABLE 37: SELECTED HENAN PROVINCE ELECTRICITY GENERATION PLANTS

Generation Plant	Owner	Fuel	Flood season capacity (MW)
Dengfeng County	China Resources Group	Coal	1,860
Hebi	Henan Investment Group	Coal	1,800
Kaifeng	China Power Investment Corp	Coal	1,200
Luoyang Mengjin	Shenhua Group	Coal	1,200
Luoyang Shouyangshan	China Datang Group	Coal	1,040
Luoyang Shouyangshan	China Resources Group	Coal	1,200
Minquan County	China Guodian Group	Coal	1,200
Nanyang Yahekou	Henan	Coal	1,900
Nanyang Tianyi	Henan Investment Group	Coal	1,200
Pingdingshan Luyang	China Power Investment Corporation	Coal	2,000
Qinbei	China Huaneng Group	Coal	4,400
Sanmenxia	China Datang Group	Coal	1,840
Xinxiang Baoquan	State Grid Corporation of China	Hydro (pumped storage)	1,200
Xinxiang Baoshan	China Huadian Group	Coal	1,200
Xiaolangdi Hydro	Yellow River Water & Hydropower Development Co.	Hydro	1,800
Xinyang	China Datong Corporation	Coal	1,250
Xuchang Longgang	China Datang Group	Coal	2,070

Generation Plant	Owner	Fuel	Flood season capacity (MW)
Yaomeng	China Power Investment Corporation	Coal	2,400
Zhengzhou Combined Cycle Power Plant	China Power Investment Corporation	Natural gas	780
Zhengzhou Rongyang	China Guodian Group	Coal	1,300
Zhengzhou Xinmi	State Development Investment Company	Coal	2,600
Zhumadian Zhongdian Combined Cycle Power Plant	China Huaneng Group	Natural gas	780

Source: Press reports and company websites

Hydropower plants constitute approximately ten percent of the province's generating capacity, with the bulk coming from two large plants on the Yellow River and one large pumped storage facility for peak regulation. Due to irregular flow along the Yellow River, average annual utilization of these plants is only 3000 hours, about 40 percent lower than thermal plants.

The Henan grid will depend on in-province coal-fired plants to meet the bulk of increased demand. A Twelfth Five-year Plan for electricity development 2011-2015 published by the Provincial government called for generating capacity to increase at an average rate of 7.6 percent to 72,000 by the end of the period, with at least 90 percent of the new increment coming from coal-fired power plants. The new coal capacity will consist primarily of the addition of new 600 or 1000 MW units at existing mine mouth plants, as well as smaller new combined heat and power plants; at the NDRC's insistence, smaller, less efficient units are being gradually phased out as new units come on-stream (Henan Energy Development Plan, 2012).

There appeared at year-end 2013 to be enough coal-fired projects in the government approval and financing pipeline to achieve the goals of the Twelfth Five-year Plan. The major generation companies are actively preparing a new series of coal-fired plants for the 2016-2020 period as well, a signal that neither government policy nor market forces appear likely to change the generation mix in Henan for the foreseeable future (**Table 38**).

TABLE 38: NEW COAL-FRED POWER PLANT CONSTRUCTION IN HENAN

Location	Capacity (MW)	Date On-stream	Owner	Comment
Dengfeng	600 (1 x 600)	2014	China Resources Group	
Gongyi County	1200 (2 x 600)	2016-2017	China Datang Group	Environmental assessment in 2013; replacing 650 MW of small units
Hebi Heqi Power Plant	1320 (2 x 660)	2015-2016	Henan Investment Company	Construction contracts signed 2013

Location	Capacity (MW)	Date On-stream	Owner	Comment
Jiaozuo Power Plant Relocation	1320 (2x660)	2014	China Resources Group	Under construction 2012; replaces 6 smaller units
Luoyang Wanji	1320 (2x660)	2015	Wanji Aluminum Group	Construction began 2013; replacing 6 x 135 MW existing units
Luoyang Yangguang Combined Heat and Power	700 (2 x 350)	2014	China Huaneng Group	NA
Sanmenxia Expansion (Datang Group)	2000 (2x1000)	2015	China Datang Group	NA
Shengchi Combined Heat and Power	600 (2x300)	2014	China Huaneng Group	NA
Xinxiang Xinzhongyi	1200 (2 x 600)	2014	Henan Investment Company Construction began 2012. Replacing 2 x 220 MW smaller units.	

Source: Media reports and company websites

4.4.3.2 Alternatives to Coal

A limited number of gas-fired power plants or CHP plants are to be built in Henan either for peaking or grid strengthening purposes; two such plants with total capacity of 1150 MW were under construction in 2014. In addition, the provincial government desires to develop nuclear power in Henan, starting with a 2000 MW proposed plant in Nanyang. Given that the central government has indicated that it will not approve construction of any nuclear power plants in inland provinces before 2016, however, nuclear power will not likely become operational in Henan before the middle of the next decade at the earliest.

While the provincial government and major generating companies are making efforts to develop distributed renewable energy in Henan, the scale is modest relative to areas with better wind and solar conditions. In 2013, only one percent of the power generated in the province came from non-hydropower renewable sources.

Based on reports of ongoing or planned construction in Sanmenxia, Nanyang, Zhumadian, and other localities, 1000-2000 MW of wind power plants will come on-stream throughout the province during 2010-2015, however, These plants are only projected to operate approximately 2000 hours per year.

After wind, biomass has been Henan's most significant source of renewable energy with 19 plants burning agricultural waste and 14 urban waste-to-energy plants with aggregate capacity of about 500 MW connected to the grid in early 2014. Pace of expansion is likely to be slow until operating problems related to raw material supply and pricing are resolved. In view of falling solar photovoltaic panel prices and the various incentives put in place by the central government, solar may likely become Henan's second most important source of non-hydropower renewable energy.

Finally, Henan's access to power from outside the province will increase significantly with the completion in 2014 of one of the Chinese government's flagship projects to develop natural resources in the far west for consumption in the heartland: the 2200 km ultra-high voltage (+/-800 KV) direct current transmission line linking the Hami region of Xinjiang to the Henan provincial capital Zhengzhou. This line will supply up to 8000 MW from coal and wind power plants that will come onstream gradually over the 2014-2016 period (Guancha Web, 2014).

4.4.3.3 Electricity Supply and Demand: Conclusion

Were electricity consumption in Henan to continue to grow at the rates of 2000-2011, it could be reasonably projected that power supply would fall short of demand looking forward from 2013. But if consumption in the metallurgical sector fails to bounce back, and electricity consumption increases at no more than 6–7 percent per year, the combination of significant expansion in coal-fired generation and the infusion of power from the Xinjiang transmission line as well as from new hydropower plants to the south and west may be sufficient to fulfill the province's needs. The success of distributed power generation, whether from renewable plants or CMM generators, will therefore depend critically on enforcement of policy mandates for favorable dispatch.

4.4.3.4 Pricing and Distribution

Wholesale Tariffs

Generating plants in Henan are dispatched by and sell their power to the Henan Electricity Company (HEC), a subsidiary of the Central China Power Grid Company (CPGC), which is in turn one of five trans-provincial companies subsidiary to the Power Grid Company of China. The HEC owns and operates the transmission and distribution infrastructure within Henan, while the CPGC operates the interprovincial transmission lines and coordinates transfers among the CPGC provinces, and from outside the CPGC region.

The NDRC directly fixes the tariffs paid by the HEC to generation plants, adjusting them on average every 18-24 months (**Table 39**). After increasing the offtake tariff paid by the grid for coal-fired power in Henan by 25 percent from 2006-2011 in response to escalating coal prices, the NDRC lowered the tariff by three percent in September 2013 as coal market prices deflated in response to slower economic growth. At the same time it increased the price of natural gas-fired power by 10 percent to compensate power plants for the jump in citygate gas prices mandated earlier in 2013 (NDRC, 2014.1).

TABLE 39: WHOLESALE POWER TARIFFS IN HENAN, 2014

Type of Generator	Tariff (CNY per kWh)[1]
Coal fired power plants[2]	0.4262
Natural gas power plants	0.609
Hydropower stations	0.28-0.342
Wind power plants	0.61
Biomass power plants	0.75

Urban Waste to energy power plants	0.5742-0.65

Source: Henan DRC 2013

[1] All tariffs are inclusive of 17 percent VAT. Wind and solar power generators as well plants burning coal tailings, or CMM receive 50 percent VAT rebates.

[2] Coal tariffs are inclusive of 0.015 CNY per kWh surcharge for flue gas desulfurization facilities which have become standard for coal-fired power plants in Henan. Surcharges of 0.01 CNY per kWh and 0.002 CNY per kWh are paid to plants which starting from 2010 have installed NOX and advanced (beyond conventional electrostatic precipitator) fine particulate emission controls facilities, respectively. Tariff for 10 out of the 14 waste to energy plants is 0.586 CNY per kWh.

The wholesale prices paid to coal-fired plants are uniform throughout the province, regardless of plant age or operating efficiencies; due to sensitivity to electricity price inflation, experiments with a bidding or auction system for wholesale power sales to the grid have not yet transpired, nor separation of the wholesale tariff into capacity and generation payment streams. Regulations enacted in 2004 were meant to allow large power users to negotiate wholesale prices directly with generators, however, to date only a handful of these types of transactions have been approved by the NDRC.

Encouraged by the drop in coal market prices from 2012-2013, the NDRC entrusted to provincial governments the rights to permit generator-end-user direct sale agreements. In late 2013, the HEC authorities recommended a group of three power plants and six large consumer power plants, to begin such negotiations on a trial basis. Aluminum plants looking for relief from high power costs hoped that direct purchase could decrease power costs by as much as 0.1 CNY per kWh, or about 15 percent, but it was not clear as of early 2014 how far the trial had progressed, and in particular, what standards of payment would be required to the HEC for its transmission services (Caijing Daily, 2013).

In Henan as in other locations in China, distributed generators of renewable energy have experienced difficulties collecting offtake price increments in excess of the coal wholesale tariffs from the grid company in a timely fashion. Biomass plants in particular, with their significant fuel operating costs, have been forced to shut down operations for periods of time as a result. The grid company's failure to pay above the coal-fired power price has, in turn, been a direct result of insufficient revenues generated from the renewable energy surcharge to electricity end-user tariffs, which are in theory meant to fully compensate the grid for the premium it must pay for renewable energy. The central government's decision in late 2013 to double the renewable energy surcharge to most electricity end-users will hopefully improve the situation, and could provide a modest impetus for the growth of renewable generation in Henan.

End-user Tariffs

As can be seen from **Table 39** and **Table 40**, small industrial and commercial users pay the highest electricity tariffs in Henan, followed by large industrial users, railroads and residential users. As is the case throughout China, chemical fertilizer manufacturers and agricultural users are charged highly favorable or even subsidized prices.

TABLE 40: ELECTRICITY END-USER TARIFFS IN HENAN, OCTOBER 2013

Category of End-user	Total Electricity Tariff[1] (CNY/kWh)	Capacity Fees	
		Load (CNY/MW-Month)	Transformer (CNY/KV-month)
Large Industry			
Ammonia/urea fertilizer plants	0.4332-0.4632	21	15
Other fertilizer plants	0.4812-0.5082	21	15
Ionic membrane choralkali plants	0.5472-0.5852	28	20
Electrolytic aluminum, caustic soda, and calcium carbide; electric furnace ferroalloys and yellow phosphorous plants	0.5712-0.6092	28	20
Railroads	0.6462-0.7392	28	20
All Other	0.5912-0.6292	28	20
Other Industry and Commerce			
Blended fertilizer	0.5922-0.6142	28	20
All Other	0.7582-0.8252	28	20
Agriculture	0.4462-0.4482	NA	NA
Residential Users			
0-180 kWh per month	0.56	NA	NA
180-260 kWh per month	0.61	NA	NA
Increment in excess of 260 kWh per month	0.86	NA	NA

Source: Henan DRC 2013

[1] Tariffs are inclusive of 17 percent VAT, as well as a series of 5 surcharges collected by the Ministry of Finance and specially allocated for: (a) key national water conservancy projects; (b) urban infrastructure; (c) renewable energy; (d and e): resettlement costs for citizens displaced by national and local reservoir construction projects. Collection efficiency for these fees, which amount to an aggregate 0.045 CNY per kWh for industrial customers, is reportedly variable.

Tariffs to industrial customers vary with the voltage at which they are interconnected with the grid, with the highest voltage customers enjoying the lowest prices. Most of the large electricity-intensive customers are likely to pay prices at the lower ends of the ranges in the table.

In addition to variations according to supply voltage, prices to industrial end-users (except railroads) also vary according to time of day as shown in **Table 41**.

TABLE 41: PEAK ELECTRICITY IN HENAN

"Valley" 12 AM-8 AM	Neither Peak nor Valley 12 PM-6 PM, 10 PM-12 AM	Peak8 AM-12 PM	Ultra-Peak 6 PM-10 PM
0.53 x Rates in **Table 40**	Rates in **Table 40**	1.5 x rates in **Table 40**	1.7 times rates in **Table 40**

Source: Henan DRC 2013

The net effect for large users such as aluminum factories that operate close to continuously is reportedly to raise the average tariff by 0.02-0.03 CNY per kWh.

The NDRC froze prices to Henan residential users from 2008 until 2012 when it introduced a policy of stepped increases in tariffs for increments consumed in excess of 180 kWh and 260 kWh per month (**Table 40** above). The first 180 kWh per month remain priced at 2008 levels, a reflection of the political as well as economic sensitivity of electricity prices.

Industrial and commercial customers carried the burden of compensating the grid for increased wholesale prices driven by the rising price of coal from 2008-2011, as prices to the large users and the smaller users rose by margins of 19 – 22 percent and 12 – 15 percent, respectively, from 2008-2011. The NDRC did not, however, pass the decreased cost of coal-fired power through to industrial end-users in 2012-2013, instead taking the opportunity to reapportion 0.0075 CNY of the tariff from the base charge paid to the grid to the renewable energy surcharge. This 0.015 CNY per kWh surcharge is now the largest of the five surcharges on power sales which are paid directly to the Ministry of Finance, with the bulk of the proceeds reallocated to the grid company to cover approved expenses related to the purchase of renewable energy, including the excess of renewable power over coal power, and the construction of special transmission facilities to link renewable plants to the grid (NDRC, 2013.1).

As noted previously, the high cost of electricity has become a flash point for Henan's large, ailing electrolytic aluminum industry. The smelters were pushed in 2012-2013 for the restoration of power discounts taken away by the NDRC in 2010, as financial losses mounted and capacity shut down in response to industry-wide overcapacity. Support was won from generators and from the provincial government for price relief of 0.10 CNY per kWh until aluminum market prices rose above a specified benchmark, after which it would reimburse the generators in full (CCTV Securities Consulting , 2012).

In December 2013, the NDRC seemed to reverse its announcement that as of January 1, aluminum smelters with electricity consumption in excess of 13,700 kWh per ton would be charged a 0.02 CNY per kWh surcharge, rising to 0.08 CNY per kWh if consumption exceeded 13,800 CNY per ton. (NDRC, 2013.2).

At the same time, however, the central government announced that it would encourage smelters to enter into multi-year negotiated supply agreements with electricity generators of the type described above. The initial proposed list of Henan enterprises to be permitted to negotiate power purchase directly with the power plants included only one of the smelting companies (Shenhuo, the largest), (Ministry of Industry and Information Technology, 2013).

Retail "tariffs" for Captive Power Plants of Industrial Enterprises

As noted above, many large enterprises have established their own power plants in Henan, both in order to ensure adequate supply and to control costs. In addition to paying the various taxes and fees to the government, consumers of captive power from plants that choose to interconnect to the public grid are required to compensate the HEC for interconnection costs, for revenue foregone, and for purchasing excess power generated. As of early 2014, these fees, which factor into the economics of CMM power plants considering interconnection to the public grid, amount to approximately 0.10 CNY per kWh of captive power consumed (Henan Electricity Supervision Office, 2014).

4.4.4 Hebi Area Electricity Market and Pricing

Hebi City, with a population of over 1 million and home to a wide range of industrial and manufacturing companies, purchased 2.5 billion kWh of electricity in 2008 from the national grid. Hebi also receives electricity from a 2,200 MW thermal power plant located in the city. Large electricity consumers include magnesium producers and cement manufacturers, such as the Tongli Cement Company which used 170 million kWh in 2007. The region's extensive dolomite resources have led to Hebi becoming a center of magnesium production, an electricity intensive industry, along with the associated manufacture of magnesium by-products.

Hebi City has grown rapidly in the last decade and while year on year growth rates have declined, the region's extensive mineral resources continue to attract heavy and light industries and the workers needed to staff them. This in turn drives the expansion of the commercial sector. As such, electricity demand in the Hebi area is expected to increase in line with national projections, at rates between 5 to 10 percent per year.

Residential customers in Hebi pay between 0.52-0.56 CNY per kWh (7-8 cents/kWh) in the region while industrial users pay 0.33-0.49 CNY per kWh (5-7 cents/kWh). Hardest hit are commercial customers who pay 0.73-0.80 CNY per kWh (11-12 cents/kWh). Grid companies buy electricity from power companies at a cost of approximately 0.3-0.4 CNY per kWh (4-6 cents/kWh).

4.5 Guizhou/South China Grid

4.5.1 Electricity Supply Demand, Organizational Structure, Dispatch and Pricing

The Guizhou power grid is one of five interconnected provincial grids which are controlled by the state-owned China Southern Power Grid Company (CSPGC). While the Guizhou Power Grid Company (GPGC) under CSPGC manages the distribution of electricity within the province, the CSPGC controls the substantial electricity transfers between the provinces. Demand for power from generating plants in Guizhou should therefore be considered in a regional context.

Coastal Guangdong Province, China's major export hub, has been the largest consumer in the region, accounting for over 55 percent of electricity consumption among the four mainland provinces of the China Southern grid (**Table 42**). Starting from the turn of the 21st century, the central government has directed massive investments into generating plants and transmission facilities to bring power from the resource-rich inland provinces of Guizhou, Yunnan, and Guangxi to supplement the coal and nuclear generating plants in Guangdong, itself under the Western Electricity to the East program. This policy has served the dual goals of promoting the development of the less well-developed inland areas, and of reducing the environmental stresses and costs of power for Guangdong, which must ship coal from distant North China or from abroad to run its own thermal power plants. In 2009, Guangdong brought in nearly a quarter of its electricity from outside the province; in 2012 and 2013, the figure was approximately 20 percent.

For the first 11 years of the new century, Guizhou was the focal point of this effort and provided the lion's share of the electricity transmitted to Guangdong, based on its favorable endowment with coal and hydropower resources, as well as its closer proximity to Guangdong in comparison with Yunnan Province. In addition to the two Tianshengqiao hydropower stations totaling 2520 MW completed in 2000 on the Guizhou-Guangxi Provincial boundary whose output is almost totally dedicated to Guangdong, state-owned companies built eight hydropower plants and 12 coal-fired plants totaling approximately 21,000 MW in 2000-2011, with the Guangdong market partly in mind. Guizhou-Guangdong transmission capacity increased to over 10,000 MW through 10 separate lines over the period, and Guangdong committed to purchase approximately 40 billion kWh per year from the Guizhou grid, on top of the 10-15 billion coming from Tianshengqiao. While actual shipments from Guizhou to Guangdong have fallen slightly short of this target, Guangdong nonetheless consumed close to one third of all the electricity generated in Guizhou in 2012 and 2013.

A number of considerations suggest, however, that Guangdong will not be nearly as strong a driver of future growth for the Guizhou electricity industry as it was from 2000-2013. Slower growth in Guangdong's demand for electricity. When the West-to-East electricity program was conceived and implemented in Guizhou between 2000-2010, Guangdong's manufacturing economy and its consumption of electricity was growing at well over 10 percent per year; the pace declined dramatically to five percent and 4.6 percent, respectively, in 2012 and 2013 as industrial consumption of electricity dropped under the combined impact of continued stagnation in OECD countries, slower real estate and fixed asset investment growth in China itself, overcapacity in many heavy industries, and the transfer of some manufacturing to areas of China with lower labor costs. There were no obvious signs in early 2014 that the macroeconomic fundamentals were changing in a way that would bring industrial electricity consumption growth back up to earlier levels, as Guangdong, whose overall economic output still increased by 8.5 percent in 2013, appears to exemplify the type of less energy-intensive growth that policy-makers desire for the country as a whole. There has been continued investment in generating facilities within Guangdong itself, including 11,500 MW of nuclear capacity due to come on-stream sometime between 2014-2018 which will be base-loaded and run almost continuously, as well as significant new coal capacity. Yunnan Province is increasingly more important as a more distant source of electricity for Guangdong with the construction of new megahydropower plants and transmission lines on the Upper Yangtze and on the Lancang (Mekong) River, as well as coal-fired plants.

The provinces to the north and east of Guizhou offer an additional potential external market for Guizhou electricity as the pace of growth slows in Guangdong. Although the rapidly growing Chongqing Municipality adjoins a coal-rich part of Guizhou, the Guizhou Power Grid Company has only made small, ad-hoc sales to Chongqing and Hunan provinces through 2013, and there has been no systematic top-down program to integrate the network of Guizhou with surrounding provinces, in significant part because the Chongqing, Hunan, and Sichuan grids are administered by the Central China Power Grid company under the State Power Grid Company of China (SPGCC), which is organizationally independent of China Southern. The announcement in 2013 that the NDRC had approved construction of the 1200 Erlang coal-fired power plant in Xishui, Guizhou on the Chongqing border, which will be partly owned by

Chongqing interests and will transmit all its power to Chongqing, suggests that there will be an uptick in sales from Guizhou to the Central China grid in coming years, though not nearly to the scale of those from Guizhou to the south (ChinaPower, 2013).

TABLE 42: CHINA SOUTHERN POWER GRID ELECTRICITY BALANCES (BILLION KILOWATT HOURS)

	2010		2011		2012		2013	
	Output	Usage	Output	Usage	Output	Usage	Output	Usage
Guangdong	323.7	406.0	371.3	439.9	376.1	461.9	393.8	483.
Guangxi	103.2	99.3	105.7	111.2	118.4	115.3	126.7	123.5
Guizhou	138.6	83.6	141.6	94.4	162.6	104.6	158.6	112.1
Yunnan	136.5	100.4	155.5	120.4	174.6	131.6	217.0	146.0

Source: CESY 2012 Tables 3-9 and 4-23; China Southern Daily Web 2014; GDSB 2014; Government of China 2014; GSB 201); YSB 2014, 2014.1

4.5.2 Guizhou Provincial Electric Power Market

As is the case for most inland provinces, Guizhou's economy has continued to grow at double digit rates throughout the second decade of the 21st century even as national economic growth has moderated (**Table 43**). This is a reflection of both government-directed investment in energy and infrastructure in the province, aimed at reducing the income gap between coastal and inland provinces and the migration of some manufacturing from the coast towards the interior. In a sharp break with past patterns, however, electricity consumption growth has trailed economic growth by increasing margins over the period, falling to 7.2 percent in 2013.

TABLE 43: GUIZHOU: GDP GROWTH AND ELECTRICITY CONSUMPTION (PERCENT)

GUIZHOU					
Economic growth	11.2%	12.8%	15%	13.6%	12.5%
Electricity consumption growth	10.5%	11.5%	12.9%	10.8%	7.2%
CHINA					
Economic growth	9.2%	10.4%	9.2%	7.7%	7.7%
Electricity consumption growth	7.2%	13.2%	11.9%	5.5%	7.5%

Sources: CESY 2013, p. 87; GSB 2010, 2011, 2012, 2013, 2014; NBSC 2010, 2011, 2012, 2013, 2014; NBSC 2010, 2011, 2012, 2013, 2014; NEA 2014

Manufacturing remains the most important driver for economic growth in Guizhou, increasing at well over 10 percent per year and accounting for approximately 75 percent of total electricity consumption in the province (**Figure 27**). As far as can be determined from published data, the reasons why growth in electricity consumption lags so significantly behind growth in manufacturing output value are a gradual diversification of manufacturing beyond electricity-intensive heavy industrial commodities such as metals, combined with greater energy-efficiency in the electricity-intensive industries.

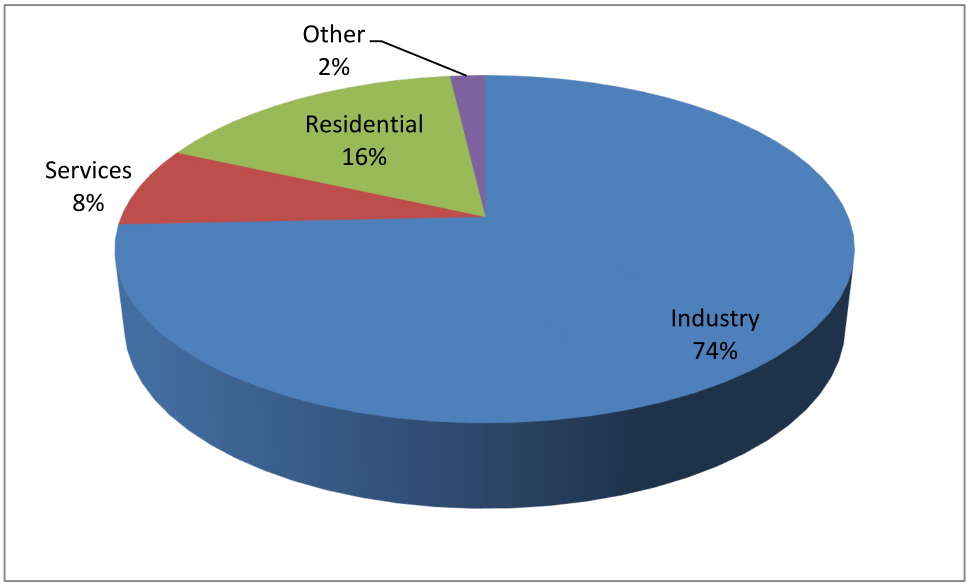

FIGURE 27: GUIZHOU ELECTRICITY CONSUMPTION BY SECTOR, JANUARY-SEPTEMBER 2013

Source: GSB 2013.1

In the first three quarters of 2013, for example, the ferrous and non-ferrous metallurgical sectors, which have accounted for close to 50 percent of industrial electricity usage in Guizhou, consumed only 4.6 and 3.9 percent more electricity than in the same period of 2012 (**Table 44**). In the case of steel and ferroalloys, slowdown in output growth appears to explain nearly all of the slowdown in electricity consumption growth. But in the case of non-ferrous metals, efficiency factors almost certainly played a significant role, given that output value grew at double digit rates, and electrolytic aluminum output increased by 7.6 percent in physical terms compared to the previous year (GSB, 2014).

TABLE 44: GUIZHOU ELECTRICITY CONSUMPTION BY SECTOR, JANUARY-SEPTEMBER, 2013

Industry	59.8	8.3%
-Electricity and Heat	12.8	19.9%
-Cement, non-metallic minerals	5.3	17.8%
-Non-ferrous metals	14.8	4.6%
-Iron and Steel	9.2	3.9%
-Coal and coal washing	3.6	1.7%
-Chemical	6.8	1.0%
Services	6.0	7.4%
Residential	13.2	2.7%
Total	80.5	7.2%

Source: GSB 2013.1

Guizhou's economy will likely continue to grow at a faster rate than the country as a whole for the medium-term future for the same reasons it has done so between 2009-2013, with the industrial economy gradually diversifying beyond commodities, but with infrastructure investment and commodities remaining important drivers for growth within the province. Assuming that China is able to maintain macroeconomic stability with an overall growth rate order of magnitude 7-8 percent per year, it is reasonable to project 10-12 percent economic growth in Guizhou, and growth in electricity demand of about 7-9 percent over a 3-5 year time frame, perhaps falling several percentage points towards the latter years of the decade. The biggest source of uncertainty is potential volatility in demand for the basic commodities on which Guizhou's economy remains disproportionately based.

4.5.2.1 Guizhou's Electricity Supply: Present and Future

In continuation of an electric power investment boom initiated at the beginning of the 21st century, in connection with the program to supply electricity to Guangdong, Guizhou's power generation capacity increased by about 17,000 megawatts, or 63 percent, to almost 45,000 MW between 2009 and 2013 (**Table 45**). The expansion included major hydropower plants on the Wujiang River system in the north of the province (Yangtze River System) and on the Beipanjiang River in the south part of the province (Pearl/Hongshui River System), as well as a number of large thermal power plants burning Guizhou's plentiful coal resources. As of early 2014, coal-fired plants accounted for 54 percent of total capacity and hydropower for 42.6 percent.

TABLE 45: GUIZHOU PROVINCE ELECTRICITY SUPPLY

	2009	2010	2011	2012	2013	Average Growth, 2009-2013
Installed Capacity (MW)	27,838	34,090	39,010	NA	44,760	12.6%
- Coal fired	17,307	17,5301	20,300	NA	24,330	8.9%
- Hydro	10,530	6,550	18,660	NA	19,080	16.0%
- Wind	0	0	40	NA	1,350	NA
Peak Load (MW)	NA	NA	11,870	NA	NA	NA
Consumption (billion KWh)	75.0	83.6	94.4	104.6	112.1	10.6%
Output (billion KWh)	138.0	138.6	137.9	161.8	158.6	3.5%
-Hydro Output (TWh)	40.1	41.6	35.5	58.2	43.6	NA
-Thermal Output (TWh)	82.6	81.1	102.4	102.7	115.0	8.6%

Source: CEPY (2012), pp. 630-631CESY (2013), Tables 3-9, 3-10, 3-11, 4-23); NDRC 2014.1

Actual power generation in Guizhou, however, only increased by an annual average of 5.4 percent from 2009-2012, significantly below the rate of increase in generating capacity and, more importantly, of electricity consumption in the province, leading to lost power export opportunities to Guangdong, and in some years restrictions on power usage in Guizhou itself. As **Table 46** shows, the major issue is limitation and the variability of generation in the hydropower plants. Even in 2012, a good water year, average utilization is only about 3100 hours per year, in contrast to coal-fired plants, which run at about 5000 hours per year. In bad years such as 2011 and 2013, the rates were 1900 and 2300 hours, respectively, meaning that the plants were operating at only one fourth of nominal generating capacity.

By the end of 2014, Guizhou's major rivers will be dammed virtually to their full potential. Future additions to hydropower capacity will be limited in scale, consisting of a maximum of a few thousand megawatts of small plants on their upstream tributaries and source waters.

Coal will thus provide the overwhelming majority of new power supply to Guizhou in the medium-term. Approximately 6200 MW of coal-fired capacity, almost all in the form of 660 MW supercritical generating mine mouth generating units are due to come onstream in 2014-2015, including the 1320 MW Erlang plant whose output will be dedicated to Chongqing Municipality to the north (**Table 46**). Over 1500 MW of smaller, less efficient coal-fired generating units in Guizhou will shut down in conjunction with the completion of the new plants, which means that the net increase in coal-fired generating capacity dedicated in whole or part to Guizhou itself will be order of magnitude 3400 MW through 2015, an annual increase of about 7 percent.

TABLE 46: NEW POWER PLANTS IN GUIZHOU

Location	Capacity (MW)	Owner	Year Onstream
Under construction			
Mamaya Hydro, Beipanjiang River	558	Guizhou Qianyuan Energy Company	2014
Panbei Coal Tailings Plant Unit 2	300	China Investment Company	2015
Panxian Coal Plant Unit 2	660 (1 x 660)	Guizhou–Guangxi Power Generation	2014
Qianbei Coal Plant	1320 (2 x 660)	CPI Generation/Jinyuan	2015
Shatuo Hydro Units 3 and 4, Wujiang River	560 (2 x 280)	Huadian Power Group	2014
Tongzi Coal Plant Unit 2	600	Huadian Generation	2014
Xingyi Zhengluwan Coal	700 (2 x 350)	Yangguang Enterprises	2014
Xishui Erlang Coal Plant	1320 (2 x 660)	CPI Power et al	2016
Advanced Permitting			
Anshun Coal Plant, Phase III	1320 (2 x 660)	Guodian Power Group	NA
Dafang Coal Plant	1320 (2 x 660)	Huarun Power Group	NA
Liuzhi Coal Plant	1320 (2 x 660)	Huarun Power Group	NA
Feasibility Study/Preliminary Permitting			
Pannan Coal Plant Expansion	1320 (2 x 660)	Guangdong Yude'an Power Group	NA
Pu'an Coal Plant	1320 (2 x 660)	CPI International	NA
Qingjiang Coal Plant	1320 (2 x 660)	Guodian Group	NA

Location	Capacity (MW)	Owner	Year Onstream
Qianxi Coal Plant Expansion	1320 (2 x 660)	CPI/Jinyuan	NA

Source: press reports and company websites

An additional 7800 MW of coal-fired capacity at 6 plants are proceeding through the planning/permitting process as of the beginning of 2014, including one plant that would be dedicated to Chongqing, and another that would largely supply Guangdong. If these plants are all ultimately built, and the pace of closure of inefficient capacity is maintained, it is reasonable to assume that a 7-8 percent rate increase in thermal generating capacity dedicated in whole or part to Guizhou could be maintained through 2017-2018.

If demand within Guizhou itself, and in Guangdong continues to moderate as projected, this implies that supply and demand for electricity within Guizhou, as well as within the larger region that Guizhou supplies could be closer balanced than in the past. There will continue to be considerable yearly variability due to the unpredictability of water conditions; in bad water years, the Guizhou grid will likely dispatch every unit that it can, whereas in good water years, it may not fully dispatch the available coal-fired capacity. Given their lower wholesale prices, the hydropower plants will always enjoy priority for dispatch. Thus the public grid could potentially require all distributed power producers such as coal mine methane power plants to produce in some years, but not all. Specifically, this could be the case if they are unable to meet the cost of coal-fired power to the grid of approximately 0.38-0.39 CNY per kWh.

4.5.2.2 Pricing and Distribution

The Guizhou wholesale price structure mandated by the NDRC and published by the Guizhou Electricity Company is shown in **Table 47** below. Grid offtake prices for coal-fired power are relatively low compared to most other provinces in China, a reflection of the use of locally mined coal with moderate production costs. Once transmission costs are accounted for, however, the cost of Guizhou coal-fired power in Guangdong is virtually the same as locally generated power in that province. Hydropower offtake prices are 17-33 percent lower than those for coal-fired power.

Off-take prices to the grid for CMM power should be, in theory, fixed at a 50 percent premium to coal, or approximate 0.56 CNY per kWh.

TABLE 47: GUIZHOU WHOLESALE POWER PRICES, DECEMBER 2013 (CNY/KWH)

I. Power Plant Offtake Prices	
Coal-Fired Plants[1]	0.3738
Hydropower Plants **- Wujiang River (7 stations)** **- Beipanjiang River** **- Nanpanjiang River Tianshengqiao I and II**	 0.2574-0.297 0.313-0.326 0.2334-2335
Wind	0.61
Solar **- Central Station** **- Distributed**	 1.0 0.7938

II. Wholesale Prices for Guizhou Power in Guangdong	
Wholesale price paid to Guizhou Grid	0.381
Delivered priced paid by Guangdong Grid to China Southern Grid	0.50
Delivered price paid by Guangdong grid for power from Tianshengqiao hydro	0.322-0.334

[1] Price is includes 0.0216 CNY per kWh surcharge for plants operating flue gas desulfurization system which have become standard, but does not include 0.008 CNY per kWh surcharge for de NOX facilities which are gradually being popularized.

Sources: Guizhou Price Bureau 2011; China Southern Grid 2012; NDRC 2013.1

4.5.3 Potential for Power Generated from CMM

Coal mine methane is among the more promising sources of new, lower carbon energy sources in Guizhou Province. Most of the 138 million tonnes of coal mined in Guizhou during 2009 came from mines with seams that contain high volumes of methane that pose a considerable safety risk. Under the relatively conservative assumption that 15 cubic meters of methane were liberated per ton of coal mined, Guizhou Province emitted approximately 2 billion cubic meters of CMM in 2009 (pure methane), enough to supply over 1,300 MW of power capacity operating at 6000 hours per year at 40 percent energy conversion efficiency.

4.6 Inner Mongolia

Inner Mongolia is a significant net supplier of electricity to outside provinces based on its abundant coal resources, sparse population and modest internal demand, and relative proximity to the Beijing-Tianjin load center (**Table 48**). The development of a series of large coal-fired plants, such as the 4200 MW Datang Tuoketuo facility near the Zhonge'er coal mines (the largest coal-fired power plant in the country), has sparked a 19 percent per year growth rate 2005-2011. This has made the formerly isolated frontier province an indispensable supplier to the North China grid area.

Inner Mongolia has the potential to become an even more significant source of power to the rest of China based not only on its coal resources, but also on the wind power potential created by the Siberian winds sweeping across its sprawling grasslands and deserts. According to official estimates, it is technologically feasible to construct 130,000 MW of wind power capacity in Inner Mongolia, a significant proportion of which can generate at world-class utilization rates (Inner Mongolia Energy Bureau, 2011; China Electricity Council, 2012).

TABLE 48: CONSUMPTION AND GENERATION OF ELECTRIC POWER IN INNER MONGOLIA 2005-2011 (BILLION KWH)

	2006	2007	2008	2009	2010	2011	2012
Consumption	88.5	116.0	122.1	128.8	153.7	183.4	201.7
Generation	141.3	193.2	218.4	224.2	248.9	297.3	317.2
-- Thermal	139.6	187.7	207.2	207.3	222.7	263.9	284.5
-- Wind	NA	NA	NA	9.8	19.9	25.9	NA

Source: CESY (2013) p. 44, 46, 97; CESY (2010); Xilinguole Government (2012)

The wind power rush of 2006-2011 resulted in the construction of 15,000 MW of grid-connected wind power plants mid-2012, 20 percent of the overall provincial electricity capacity and nearly half of the total, national wind capacity. The provincial Energy Bureau has announced a target of 30,000 MW and 50,000 MW of wind capacity by 2015 and 2020, respectively.

A host of issues such as the failure of longer lead-time grid infrastructure construction to match the pace of short-turn power plant installation as well as dispatch issues have prevented the Inner Mongolia wind plants from operating at more than about 2000 hours per year, perhaps two thirds of their potential. The complex structure of the region's power industry creates particular challenges.

4.6.1 Export of Inner Mongolian Power: Structural Issues

Inner Mongolia is served by two separate power grids: (1) the western and central regional grid operated by the Inner Mongolia Power Grid Company (IMPGC), and; (2) the considerably smaller northeastern regional grid operated by the Northeast Inner Mongolia Power Grid Company (NEIMPGC). The Northeast Inner Mongolia grid is in essence an extension of the northeastern grid covering the three adjacent Manchurian provinces, and the NEIMPGC is a wholly owned subsidiary of the Northeast China Power Grid Company. **Table 49** provides an overview of the Inner Mongolian grid consumption and generation by grid areas.

TABLE 49: EASTERN AND WESTERN INNER MONGOLIAN GRID OVERVIEW, 2011

Consumption (billion kWh)	147	33
Generation (billion kWh)	227	70
-Wind	16	9

Source: Xilinguole League Government (2012)

Despite the significance of western/central Inner Mongolia to Beijing's power supply, the IMPGC is the only provincial grid company in China owned by the provincial government rather than one of the five trans-provincial power grid companies. The largest coal-fired power plants, which send the entirety of their power to the Beijing-Tianjin load center, are dispatched directly by the North China Power Grid Company. The smaller coal-fired plants and all of the wind plants in the west/center are dispatched by the IMPGC, which negotiates a daily quota with the North China Grid Company for the supply of additional power to the Beijing-Tianjin region. This "double dispatch" system for Western Inner Mongolia wind power plants creates difficulties for the North China regional grid to fully integrate them into overall dispatch planning.

In view of the fluctuations in wind power plant output due to the weather, the grid companies are unwilling to depend on wind for more than about one third of power supply at any given time in order to maintain grid stability. The highest level that has been achieved in Inner Mongolia is about 28 percent, and the average is significantly lower.

Aside from coordination issues between the grid companies, wind plants are limited both in Inner Mongolia and the North China grid area by the necessity to maintain coal-fired (and in Beijing, gas fired) CHP plants at close to full load for heating purposes at precisely the winter season when the wind conditions are at their best for power generation in Inner Mongolia. The difficulties for the grid of accepting wind power at low load conditions at night are a further limiting factor.

The central government is pushing for the State Power Grid Corporation (the umbrella company that owns both the North China and Northeast China trans-provincial grids) to exert maximum effort to accommodate wind power in order to reduce carbon emissions. New transmission facilities constructed by both the IMGC and the North China Power Grid Company have partially alleviated the severe problems of connectivity, which reached a head in 2009-2010. The State Power Grid Corporation has proposed as many as 6 UVH transmission lines to connect Western Inner Mongolian wind and coal resources to East and Central China (Inner Mongolia Energy Bureau, 2011). Implementation of these plans will provide a stimulus not only to wind power, but also to Inner Mongolia's coal-fired power industry, which can provide the flexible back-up to variable wind power generation.

As noted above, the integration of the eastern Mongolian grid with the Northeast China trans-provincial grid is fuller than in the west. An important issue for both wind and coal fired plants in East Inner Mongolia is the growth in of demand for power of the Northeast provincial area itself (i.e., the three Manchurian provinces), which, at about 7 percent 2005-2009, significantly lagged behind the rest of China (CESY, 2010).

4.6.2 Consumption of Electricity within Inner Mongolia

Demand for power in Inner Mongolia itself increased at an 18 percent rate from 2005-2011, considerably higher than the national average, as new generation facilities came online and the region's resource extraction economy accelerated. In addition to coal, Inner Mongolia produces and refines almost all of China's rare earth metals, and about 10 percent of its electrolytic aluminum.

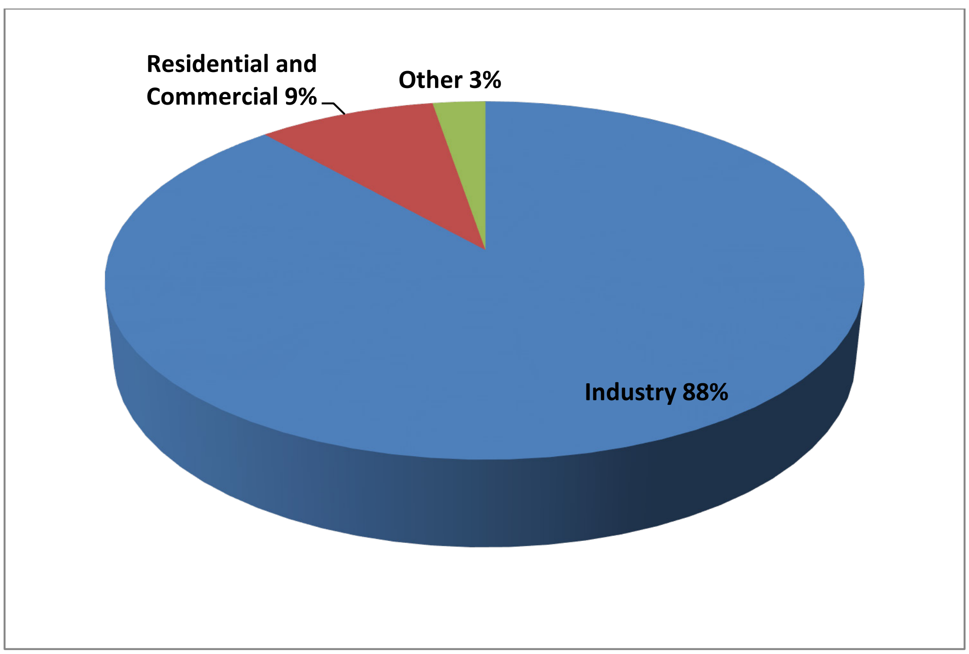

FIGURE 28: INNER MONGOLIA ELECTRICITY CONSUMPTION BY SECTOR, 2012
Source: CESY (2013) p. 161

Figure 28 shows the extent to which industry dominates electricity consumption in the Inner Mongolia Region. Industry's share of total consumption in Inner Mongolia has been almost 15 percent higher than China as a whole, while the share devoted to commercial and residential consumption has been about nine percentage points lower.

The economic slowdown of the first half of 2012 has had a particularly dramatic impact on demand for electricity in Inner Mongolia in view of this industry-skewed demand structure. If, as the central government hopes, resource extraction growth moderates over the medium-term as the structure of the economy gradually shifts in the direction of consumption, demand for power in Inner Mongolia is unlikely to grow at rates greatly exceeding the national average. With a population of only 25 million people (1.8 percent of the national total) and an urbanization ratio that had already reached 57 percent in 2011, there is a greater limit in Inner Mongolia in the degree to which personal consumption can drive growth in electricity usage (Inner Mongolia Statistical Bureau, 2012).

4.6.3 Inner Mongolia Electricity Pricing and the Potential for CMM Power

Potential CMM power generators in Inner Mongolia will deal with power grid companies more experienced than in any other part of China in dealing with variable supply from small power suppliers. But as a practical matter they will have to compete with the wind power plants for dispatch in a province that has a much stronger stake in wind power than in CMM. To the extent that they are dispatched, it can be assumed that the CMM power plants will not be able to sell their output at more than the 0.51 CNY per kWh mandated for wind (**Table 50** and **Table 51**).

TABLE 50: WHOLESALE PRICES FOR POWER GENERATED IN WESTERN INNER MONGOLIA, MID-2012

Coal-fired power sold to the Inner Mongolia Power Grid Company	0.3109 CNY/kWh
Coal-fired power dispatched directly to Beijing-Tianjin-Tangshan grid	0.3731 CNY/kWh
Coal-fired power sold by Inner Mongolia Power Grid Company to Beijing-Tianjin Grid	0.375 CNY/kWh
Power from wind plants installed after July 2009	0.51 CNY/kWh

Source: NDRC (2011.6); NDRC (2009.3); NDRC (2009.2)

TABLE 51: INNER MONGOLIA ELECTRICITY PRICES TO END-USERS, MID-2012

Residential users	0.42-0.43 CNY/kWh
Commercial and small industrial users	0.571-0.684 CNY/kWh
35 kV Industrial users	0.472 CNY/kWh

Source: NDRC (2011.6)

Large industrial users are also assessed fixed charges of 28 CNY per KW per month and 19 CNY per kV per month.

5. Gas Market

5.1 National Gas Market

From 2006-2012, coal continued to supply 70-71 percent of China's energy needs despite multiple central government exhortations and projections for its share to decline. Conversely, despite years of double digit growth in the gas industry, the share for natural gas only increased from 3.0 percent in 2006 to about 5.6 percent in 2012 (CESY, 2013).

The NEA's Draft Twelfth Five-year Natural Gas Development Plan called for the natural gas percentage to reach about 8 percent by year-end 2015, and it is commonly projected that the percentage will exceed 10 percent by 2020 (Xinhuanet, 2012).

The central government appears more serious than ever about moderating the rate of growth, lowering the rate of investment relative to consumption, and reducing local and global environmental degradation in order to improve the quality of life of the Chinese people. This is embodied in such targets as seven percent annual GDP growth, reduction of energy consumption and CO_2 emissions per unit of GDP by 16 percent, and virtual zero percent growth in coal production.

Outside factors such as the reduction in trade surplus volume, which has financed the investment boom, reinforce these trends. And notably, at least as of mid-2012, the central government was resisting pressures for a major investment-driven stimulus program to counteract the economic drop-off resulting from tightening of real estate lending and global economic slowdown.

All of these trends impact the output growth and energy consumption of commodities such as steel and cement which depend on coal rather than natural gas. Increased urbanization, cleaner air, and reduced carbon emissions all correlate positively with natural gas consumption. Finally, the central government appears to be committing the capital necessary to match increased natural gas supply with rapidly growing demand.

5.1.1 Recent Trends in China's Natural Gas Market

The natural gas market in China has experienced a surge of historic proportions since the turn of the century (**Table 52** and **Figure 29**). This has been a result of the government's decision to invest billions in production facilities, long distance pipelines and liquefied natural gas (LNG) receiving terminals in order to introduce natural gas into the major eastern and southern coastal population and industrial centers. Gas consumption has grown at a sustained 17 percent rate since 2000, far in excess of original official expectations as consumers of all kinds experience the benefits of a clean, convenient fuel.

TABLE 52: CHINA NATURAL GAS MARKET DEVELOPMENT, 1995-2012

	Production (million cubic meters)	LNG Imports		Pipeline Imports	Exports (million cubic meters	Consumption (million cubic meters)
		(thousand tonnes)	Million m^3 equiv.			
1995	17,900	NA	NA	NA	NA	15,253
2000	27,200	NA	NA	NA	3,140	23,531
2001	30,300	NA	NA	NA	3,040	NA
2002	32,700	NA	NA	NA	3,200	27,544

2003	35,000	NA	NA	NA	1,873	34,829
2004	41,500	NA	NA	NA	2,440	40,798
2005	49,300	NA	NA	NA	2,970	46,474
2006	58,539	698	1,020	NA	2,900	56,141
2007	69,310	2,931	4,280	NA	2,600	70,520
2008	80,300	3,336	4,870	NA	3,250 (est)	81,290
2009	85,270	5,341	8,080	NA	3,210 (est)	89,520
2010	94,848	9,340	13,670	6,400	2,900 (est)	106,941
2011	102,689	12,200	17,810	13,000	2,900	130,530
2012	107,153	14,676	20,293	21,805	2,890	146,300

Source:CESY (2013) p. 43, 85, 105; CESY (2010), p. 119, 105, NBSC (2007); China Customs (2009.2); China Energy Bureau January 28, 2011; China Reform Daily (2012); NBSC (2012); Wanlong Securities Net February (2012). (est) indicates estimated.

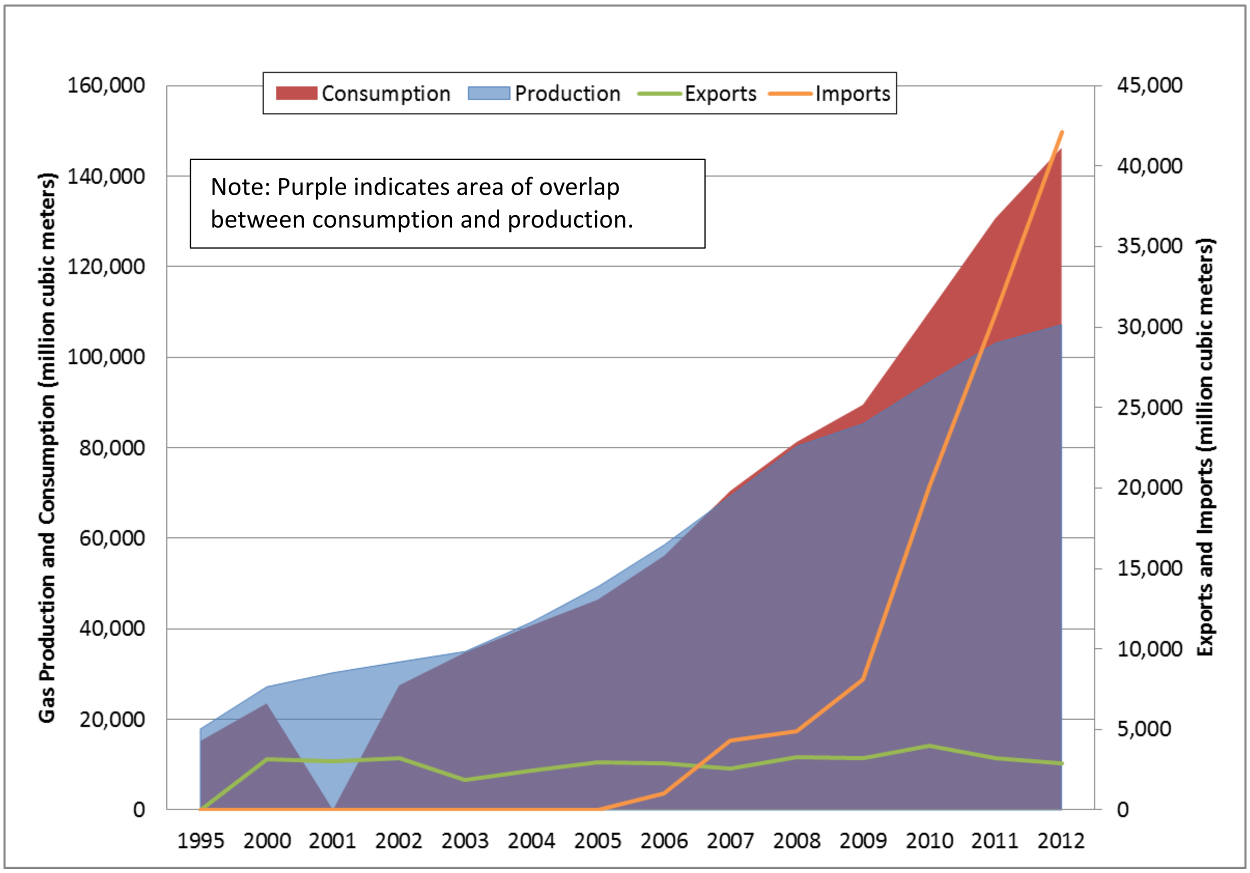

FIGURE 29: CHINA NATURAL GAS MARKET DEVELOPMENT, 1995-2012

The government now projects that consumption will double to 260 billion cubic meters in 2011-2015, and to 350 billion cubic meters in 2020 and is making hard commitments to import ever larger quantities of gas from outside of China to fulfill this goal as China's domestic production fails to keep up with demand (People's Daily Net, 2012).

The natural gas sector has not been totally immune to the downturn in China's economy in 2012. With new supply from Central Asia entering the market in Guangdong Province, one of the most voracious new consuming provinces, a glut of natural gas supply was reported for the first time ever as power plants slowed down (ICIS, 2012). This glut appears to have been mainly a local, short-term phenomenon reflecting temporary slowdown in electric power production, which accounted for about 80 percent of the province's gas consumption (ICIS, 2012). Over the longer term, there is still every reason to expect natural gas demand to continue to grow rapidly as projected.

Natural gas use as a clean, convenient urban household and commercial fuel represents precisely the kind of consumption and improvement in quality of life that is the centerpiece of the government's Twelfth Five-year Plan. So does fuel switching from fuel oil, coal gas and coal in the industrial and power sectors. The potential for growth in these end-uses is nowhere close to exhausted (**Section 5.1.1.1**). Given its enormous financial commitment to the development of natural gas supply, furthermore the central government is likely to take whatever administrative measures are necessary to reinforce these macroeconomic and environmental drivers for gas demand.

5.1.1.1 Structure of Demand

Table 53 and **Figure 30** below show China's natural gas consumption by sector.

TABLE 53: CHINA NATURAL GAS CONSUMPTION BY SECTOR (MILLION CUBIC METERS)

	2009		2010		2011		2012	
	Volume	%	Volume	%	Volume	%	Volume	%
TOTAL	89,520	100.0%	106,941	100.0%	130,530	100%	146,300	100%
INDUSTRY	57,790	64.6%	68,092	63.7%	83,995	64.3%	94,675	64.7%
Mining	*12,293*	*13.7%*	*13,414*	*12.5%*	*13,193*	*10.1%*	*13,950*	*9.5%*
Petroleum Extraction	11,740	13.1%	12,955	12.1%	12,604	9.7%	12,294	8.4%
Manufacturing	*32,114*	*35.9%*	*35,770*	*33.4%*	*48,307*	*37.0%*	*57,272*	*39.1%*
Petroleum Processing and Coking	2,672	3.0%	4,004	3.7%	6,833	5.2%	9,889	6.8%
Chemical Manufacturing	17,684	19.8%	18,728	17.5%	23,348	17.9%	25,034	17.1%
Non-metallic mineral manufacturing	4,462	5.0%	4,272	4.0%	6,376	4.9%	6,872	4.7%
Iron and Steel Making	1,881	2.1%	2,042	1.9%	2,856	2.2%	3,312	2.3%
Nonferrous Metals	673	0.8%	906	0.8%	1,394	1.1%	2,605	1.8%
Manufacturing, other	4,742	5.3%	5,818	5.4%	7,500	5.7%	9,560	6.5%

	2009		2010		2011		2012	
	Volume	**%**	**Volume**	**%**	**Volume**	**%**	**Volume**	**%**
Utilities	*13,382*	*14.9%*	*18,907*	*17.7%*	*22,495*	*17.2%*	*23,452*	*16.0%*
Electricity and Heat	12,791	14.3%	18,080	16.9%	21,590	16.5%	22,502	15.4%
TRANSPORT, STORAGE, POST	9,107	10.2%	10,670	10.0%	13,835	10.6%	15,451	10.6%
COMMERCIAL	2,492	2.8%	2,773	3.0%	3,548	2.7%	4,059	2.8%
RESIDENTIAL	17,767	19.8%	22,690	21.2%	26,438	20.3%	28,827	19.7%
OTHER	2,364	2.6%	2,600	2.4%	2,714	2.1%	3,288	2.2%

Source: CESY (2013)p. 84

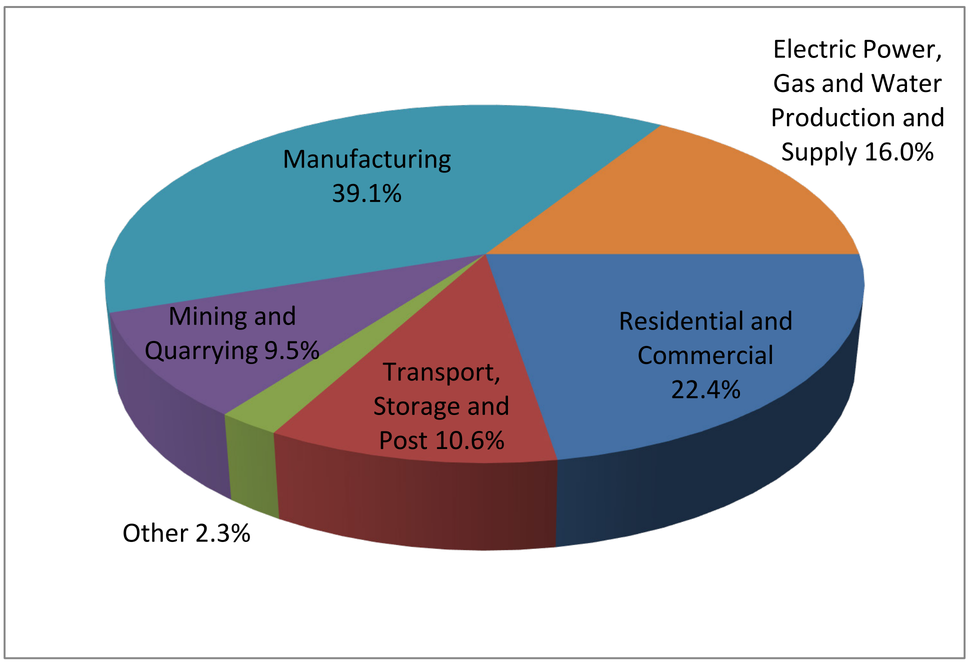

FIGURE 30: CHINA'S NATURAL GAS USAGE BY SECTOR

5.1.1.2 Civil and Commercial Use of Natural Gas

An NDRC white paper in 2007 listed urban civil use – residential and commercial – as the top level priority for the gas industry (NDRC, 2007.2). Civil use grew by 20 billion cubic meters between 2000 and 2009, accounting for 30 percent of the growth in consumption and rising to 22 percent of the absolute total, as local governments in all areas of the country scrambled to obtain access to natural gas, and private as well as publicly owned natural gas distribution networks sprouted up in cities all over the country (**Figure 31**).

Only 25 percent of the reported 690 million people living in Chinese cities, suburbs, and towns had access to natural gas at year-end 2011. Entire provinces, such as Guizhou, Yunnan, and Guangxi offered almost no gas to urban residents, and even developed provinces such as Jiangsu and Guangdong offered only 30 percent or less.

Most of those urban households that do burn gas, use it only for cooking and hot water, and not for space heating, for which they depend mainly on coal fired district heating plants. The substitution of gas-fired district heating or direct gas burning for coal-fired district heating is a major source of latent demand for gas. In short, civil use may well be the most significant driver of natural gas demand in the medium-term.

Figure 31 shows China's urban population with access to natural gas by province.

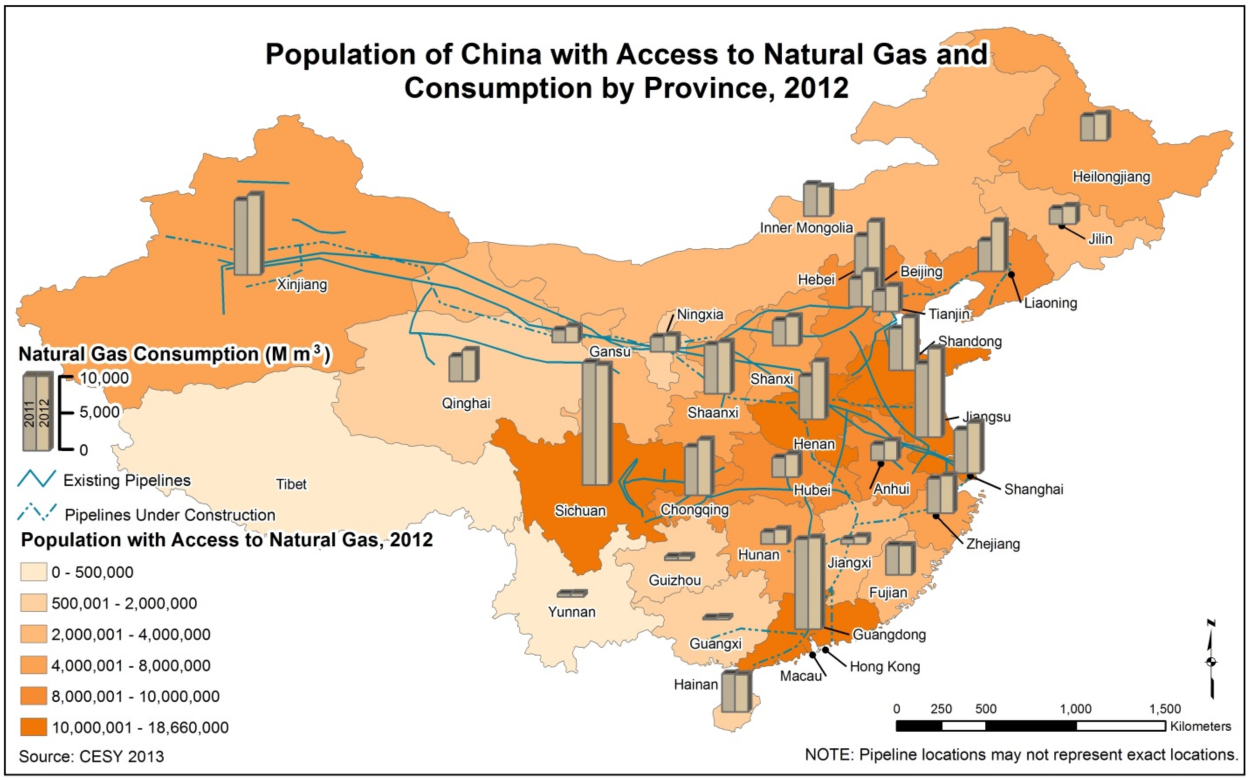

FIGURE 31: POPULATION OF CHINA WITH ACCESS TO NATURAL GAS AND CONSUMPTION BY PROVINCE, 2012
Source: China Today (2010), NBSC (2012), CESY (2013)

5.1.1.3 Industrial Fuel

The central government's white paper on natural gas use called for substitution of natural gas for fuel oil and coal gas in industry, where possible. Industrial fuel oil consumption dropped nearly half over 2005-2009 to 14 million tonnes, accounting for a 15-16 billion cubic meter increase in natural gas consumption over the period[3] (CESY, 2010). The Yaohua Glass Plant in Qinhuangdao, which switched from coal gas to natural gas, accounted for about 400 million cubic meters of new natural gas consumption. As local governments press to reduce emissions, gas can be expected to replace not only fuel oil and coal gas, but also coal in sectors such as food processing, textiles and non-ferrous metals manufacturing, where coal is still the dominant fuel.

By contrast, the volume of gas consumed as a chemical feedstock, the main end use prior to 2000, started to decrease in 2007 – a trend that is expected to continue. The government's 2007 white paper forbade the construction of new ammonia and methanol plants using natural gal feedstock, and a number of existing ones are converting to other fuels, including coke oven by-product gas.

5.1.1.4 Power Sector

Combined cycle electric power plants accounted for 12.5 billion cubic meters, or about 20 percent of the increase in gas consumption from 2000-2009. Approximately 20,000 MW of large combined cycle power plants were built, driven both by acute power shortages and by central and local government concern that there be firm off takers for the gas coming through the new pipelines and LNG import terminals.

There is enormous room and obvious environmental incentive for growth of gas-fired power, which only accounted for about three percent of total national generating capacity in 2011. However, the pace of combined cycle power plant construction slowed down noticeably from 2010-2012. Unexpectedly strong demand for gas in the residential/commercial sector decreased pressure to build combined cycle power plants, and it remained unclear as of mid-2012 how quickly the use of natural gas in power plants would increase.

The NDRC's 2007 gas utilization white paper listed power as a second tier priority for gas consumption, and the pace of combined cycle power plant construction clearly slowed down starting from about 2010. In addition, because of the high price of gas relative to coal (at 600 CNY per tonne for 5500 kcal/kg coal and 2.0 CNY per 38,000 kJ cubic meter of gas), fuel expenses per kWh for coal are about 50 percent cheaper than gas. This has led the grid to use gas-fired plants as peak regulation plants producing at 3500-4000 hours per year, rather than base-loaded plants, despite their high thermal efficiency.

Under these conditions, a return to rapid growth for combined cycle power plants may require a change in economics of gas relative to coal and/or a more definitive top-down mandate from the government to substitute for coal-fired power. A middle of the road projection by the State Power Grid Corporation suggested that the proportion of gas-fired power generation capacity might rise from 3 percent to 6 percent from 2010-2020 which, assuming 6 percent per year growth in power generation capacity, is equivalent to an approximately 15 percent per year increase in gas-fired power output.

5.1.1.5 Automotive Sector

NDRC listed automotive fuel as one of the encouraged uses of natural gas in its 2007 white paper, and the rapid development of a gas-based vehicle industry is a distinctive feature of China's natural gas development. Transportation accounted for approximately one eighth of the increase in natural gas

[3] Based on assumed thermal value of 42,400 kJ/kg for fuel oil, and 38,000 kJ/m^3 for gas.

consumption from 2000-2009, and over 10 percent of annual consumption by the end of the period. By the end of 2011, the number of vehicles burning either CNG or LNG reached a reported one million out of the total national inventory of 100 million automotive vehicles.

Natural gas vehicles' low conventional pollutant emissions levels have drawn the interest of both central and local governments sensitive to the significant contribution of sustained double digit growth in vehicle inventory to poor air quality. Low prices of natural gas relative to gasoline (priced in mid-2012 at the equivalent of $4.03-$4.39 USD per gallon) have enabled consumers to save as much as 40 percent on fuel fees. The costs to convert a car to run on CNG fuel, rather than gasoline, can be as low as CNY 1700 ($268 USD).

The use of CNG or LNG has also been attractive to gas distribution companies in areas such as Chongqing and Sichuan where CNG has been established for decades. In many cases, they have they been able to earn a higher return on sales of CNG than other forms of natural gas. CNG has also allowed distribution companies in smaller market areas that are just beginning to introduce natural gas, to develop some market volume quickly without having to invest initially in expensive distribution networks.

The lack of a fully developed network of CNG filling stations remains a major obstacle to a more rapid popularization of natural gas vehicles. Despite a series of government incentives, such as fast track approval process and credit support from lending institutions during the economic stimulus program of 2009-2011, filling stations have been slow to appear in the major urban centers of the eastern part of the country where pressures to ensure supply for civil users are particularly acute, and where there is no established history of CNG use.

In addition, the central government is concerned about too much gas being diverted to motor vehicles away from even higher priority end-uses, and about the complications that large vested interests in low CNG prices would pose to raising natural gas upstream prices to more accurately reflect both cost and value. Therefore, it is beginning to enforce regulations that require the sale prices of CNG and LNG used in motor vehicles to be fixed at a level no lower than 75 percent than gasoline prices, which are pegged to the international oil market and are adjusted whenever that market moves significantly. Given these cross-pressures at the government level, it remains to be seen to what extent natural gas will become more than a niche fuel for the automotive sector, and how strong a market the automotive industry will be for natural gas going forward.

5.1.2 Structure of China's Natural Gas Industry

China's onshore conventional oil and gas industry is essentially a duopoly of the central government-owned conglomerates China National Petroleum and Natural Gas Group Corporation (CNPC, with a listed arm known as "Petrochina"), and the China Petroleum and Chemical Corporation Group (Sinopec). CNPC has consistently been the major player in natural gas, accounting for 75.5 billion cubic meters, or 84 percent of total 90 billion cubic meter output in 2011. China National Offshore Oil Corporation (CNOOC), the third of the central government owned conglomerates, controls offshore production, which totaled approximately 13 billion cubic meters in 2011.

CNPC and Sinopec own and operate trunk transprovincial pipelines transporting conventional oil and gas, with CNPC controlling the bulk of the capacity. Certain intraprovincial pipelines branching off from the trunklines are owned by the major companies, but the majority, including many that could be considered long-distance pipelines, are owned by provincial government companies.

The allocation of CNPC and Sinopec gas to the various provinces has been determined not through market forces, but through a bargaining process between the provinces themselves and the NDRC, through which the gas producing areas and the coastal provinces have been given clear priority over non-gas producing interior provinces. The basic quotas have generally been established at the time the pipelines are built, with exact allocations decided on an annual basis. Except at the margins, neither CNPC nor Sinopec are free to decide which customers their fields and pipelines will serve.

The downstream distribution sector, by contrast, is characterized by a striking variety of ownership models and a great deal more freedom than compared to the upstream sector. Municipally owned utilities still predominate in the largest cities such as Beijing, Shanghai, Tianjin, Guangzhou, and the core city of Chongqing. But new players have been allowed to enter, including subsidiaries of the upstream major utilities, and, most importantly, private companies.

The private companies have made major inroads in second-tier cities, particularly those which have only gained access to natural gas over the past 5-10 years. They have either created new utilities or consolidated existing ones previously owned by the government, forming approximately one half-dozen much larger, modern, and mostly publicly listed companies with holdings in multiple cities across provinces. The private companies have better access to technology, capital, and management expertise. This privatization has helped to markedly accelerate China's consumption of natural gas in urban areas (**Figure 32**).

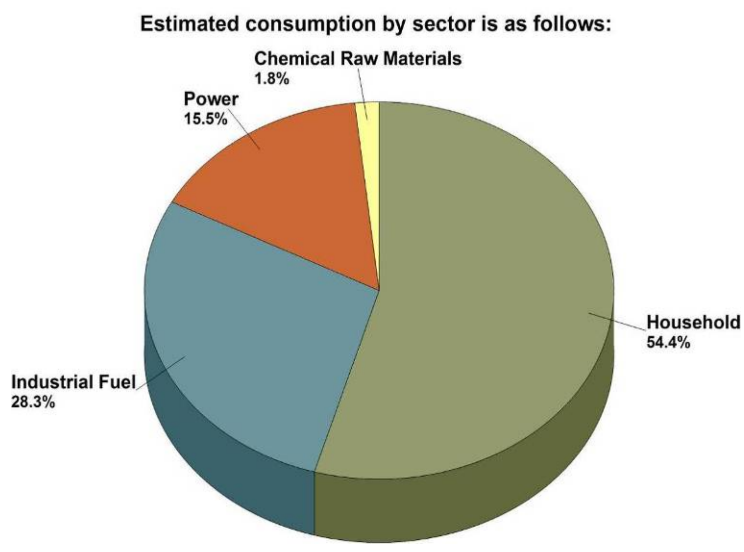

FIGURE 32: PROJECTED SECTORAL END USE BREAKDOWN OF SINOPEC SICHUAN-SHANGHAI PIPELINE GAS, IN COMMISSION 2010

Today, these companies compete to invest in China's rapidly growing urban markets, using capital funds raised on domestic, Hong Kong, and other stock markets. These companies aggressively bid on city gas assets at auction, acquire the equity interests of city gas enterprises through direct negotiation, or obtain indirect control of city gas operating concessions by jointly constructing and operating the systems with municipal-owned city gas enterprises.

The companies include mainland Chinese companies such as China Gas Holdings and Xin'ao, and Hong Kong companies such as Towngas, the territory's gas distribution utility. China Gas Holdings Limited (China Gas), listed on the Hong Kong Main Board, holds exclusive piped gas development rights in some 64 cities and regions in China. The company, incorporated in 2002, has a pipeline network more than 15,000 km long that serves 3.2 million household users and nearly 19,000 industrial and commercial users. In addition to city gas systems, China Gas also owns six high-pressure intermediary natural gas pipelines and 11 LPG terminals along China's southeast coast with capacity of 220,000 tonnes and LPG storage facility with 270,000 cubic meters capacity (Liu, 2008).

Like the other nationwide private companies, ChinaGas is an important potential customer for developers of coal mine methane utilization projects. It is, for example, the distributor in the city of Huainan in Anhui Province, one of the focus projects of this study. Three Gorges Gas Group, a Chongqing-based private distributor, is the owner and operator of China's first medium-distance (100 km) coal mine methane pipeline connecting Southeast Shanxi Province with Bo'ai in Henan Province.

5.1.3 Natural Gas Supply

The 17 percent growth in domestic natural gas production from 2000-2007 slowed down to 10.5 percent from 2007-2011, necessitating the import of 30 billion cubic meters of gas in 2011, approximately 23 percent of total consumption. The draft of the government's Twelfth Five-year Plan for natural gas projects that domestic conventional natural gas production in 2015 will only rise to about 120 billion cubic meters from the 2011 level.

The government hopes that nonconventional gas could supply an additional 50 billion cubic meters, including 20 billion cubic meters of coalbed and coal mine methane and 30 billion cubic meters from plants converting coal to methane, as well as perhaps 6.5 billion from the country's nascent shale gas industry. At these levels, natural gas imports of order of magnitude 90 billion cubic meters would be required to meet targeted 260 billion cubic meter consumption in 2015 (People's Daily Net, 2012).

5.1.3.1 Onshore Gas Production and Pipeline Transmission

Domestic Conventional Gas

China enjoys only modest domestic endowments of conventional natural gas, and the great majority of known deposits are located in western areas distant from population and industrial centers. Over 80 percent of China's production, and almost all of the growth of the past decade has come from the following fields:

- Tarim Basin in the far northwestern desert of Xinjiang Autonomous Region (Province), developed exclusively by CNPC;
- Changqing Oil and Gas fields in the Ordos Basin in the Shaanxi-Inner Mongolia border region (output counted under Shaanxi Province), over 90 percent of which has been developed by CNPC. Despite difficult technical conditions and low permeability, these field are now the largest gas producer in the country;

- The Sichuan gas fields, the only major deposits whose development predates the 21st century. These fields were exclusively developed by CNPC until Sinopec commissioned the 10 billion cubic meter per year Puguang field in 2010, which accounts for the jump in Sichuan production starting from that year; and
- The Caidam basin in Qinghai Province, another CNPC development.

Most of the remainder of China's conventional gas output is associated gas from oilfields such as Daqing in Heilongjiang Province (CNPC) and Puyang in Henan (Sinopec). CNOOC exploits one large offshore field in the South China Sea, which exports most of its production to Hong Kong as well as smaller deposits off Shanghai and in Bohai Bay to the north. **Table 54** shows China's natural gas production by province.

Barring spectacular new discoveries, technical breakthroughs, and/or changing economics the CNPC expects only incremental increase from most of its existing deposits in coming years. Production in the Xinjiang Tarim Basin may already have peaked in 2010.

TABLE 54: CHINA NATURAL GAS PRODUCTION BY PROVINCE (MILLION CUBIC METERS)

Provinces and Municipalities	2006	2007	2008	2009	2010	2011	2012
North							
Beijing	NA	NA	NA	NA	NA	NA	NA
Tianjin	1,050	1,334	1,401	1,436	1,719	1,843	1,873
Hebei	655	714	874	1,087	1,270	1,220	1,336
Shanxi	602	NA	521	NA	NA	NA	NA
Inner Mongolia[1]	5,307	7,050	NA	NA	NA	NA	NA
Northeast							
Liaoning	1,194	872	871	810	800	720	721
Jilin	241	522	874	1,162	1,370	1,500	2,270
Heilongjiang	2,452	2,550	2,710	3,004	3,000	3,100	3,368
East							
Shanghai	564	507	429	403	303	300	298
Shandong	855	784	885	905	533	520	600
Central-South							
Henan	1,868	1,576	1,122	2,958	672	500	501
Guangdong	4,894	5,247	6,078	5,843	7,840	8,330	8,352
Hainan	205	203	232	186	180	200	180
Southwest							
Chongqing	647	500	954	60	120	46	40
Sichuan	15,995	18,746	19,423	19,356	23,765	26,553	24,226
Northwest							
Shaanxi	8,047	11,010	14,420	18,952	22,349	27,221	31,130
Qinghai	2,503	3,430	4,365	4,307	5,609	6,501	6,428
Xinjiang	16,420	21,020	23,589	24,539	24,990	23,533	25,301
Total	63,499	76,065	78,748	85,008	94,520	102,087	106,624

Source: CESY (2013) p. 43; CESY (2010); Sichuan, Shaanxi, Qinghai, Sichuan, Heilongjiang, Tianjin Statistical Bureaus (SB)

As noted above, the development of the western gas fields and the introduction of gas to eastern China in the 21st century would not have been possible without a central government decision to build the country's first long-distance gas pipelines (**Table 55**). The net impact of these projects through the end of 2010 is as follows:

- The capability to transport almost 30 billion cubic meters per year to Shanghai, the Yangtze Delta Provinces, and areas in between through the CNPC flagship 3900 kilometer first West-to-East pipeline from Xinjiang in the far northwest (17 billion cubic meters) and the Sinopec pipeline from Sichuan/Chongqing (12 billion cubic meters). The bulk of the first West-to-East pipeline throughput is consumed in Jiangsu Province.
- The capability to transport 30 billion cubic meters per year from the Changqing Gas field to Beijing and areas in between through three CNPC pipelines. Some gas from these pipelines has been diverted to the Yangtze River delta through a connector pipeline linking them to the West-to-East line.
- The supply of an estimated 10 billion cubic meters to northern and Yangtze Valley interior provinces such as Shanxi, Henan, Anhui, Hubei, Hunan and Jiangxi through the above-mentioned lines, plus an additional CNPC three billion cubic meter per year pipeline from Chongqing to Wuhan, the Hubei capital on the Yangtze River.

Thousands of more kilometers built by provincial gas companies move gas from these trunkline transfer stations to distribution company citygates. As noted above, the allocation of the gas is determined by bargaining between the provinces, the NDRC and the producers. The results of this bargaining have tended to favor the coastal provinces and the provinces in which the gas fields are located, at the expense of the interior provinces on the pipeline route.

TABLE 55: CHINA MAJOR LONG-DISTANCE GAS PIPELINES, 1997-2011

Pipeline	Length (km)	Design Capacity (million cubic meters)	Gas Source	Date in Operation
In Operation				
First West-to-East pipeline: Xinjiang - Shanghai: CNPC	3,900	12,000 (original) 17,000(expanded)	Tarim Basin, Xinjiang, and Changqing	2005 2009
Second West-to-East Pipeline: Xinjiang-Guangdong: CNPC	8,700 (including major branch lines)	30,000	Turkmenistan, Uzbekistan	2010-2012
Sichuan Gas to the East Chongqing-Shanghai: Sinopec	2170	12,000	Puguang Gas field, Sichuan	2010
Jingbian County	896	15,000	Changqing , Shaanxi-	2010

Pipeline	Length (km)	Design Capacity (million cubic meters)	Gas Source	Date in Operation
		In Operation		
(Shaanxi)-Beijing Number 3: CNPC			Inner Mongolia	
Jingbian County - Beijing Number 2: CNPC	935	12,000	Changqing	2006
Jingbian County - Beijing: CNPC	853	3,500	Changqing	1997
Chongqing-Wuhan (Hubei): CNPC	695	3,000	Sichuan Gas fields	2005
Yizheng (Jiangsu)-Anping (Hebei) connector pipeline: CNPC	886 (1498 including branches)	9,000	West-to-East and Second Jingbian-Beijing pipelines	2006
Huaiyang (Henan)-Wuhan connector pipeline: CNPC	475	1,500	Chongqing-Wuhan and West-to-East pipelines	2007
Yulin (Shaanxi)-Tai'an (Shandong): Sinopec	1045	3,000	Ordos Basin Yulin Gas field	2012-2013
Sebei-Xining (Qinghai) - Lanzhou (Gansu): CNPC	953	2,000	Sebei Field, Qinghai	2001
Jingbian County (Shaanxi)-Xian: Shaanxi Province Gas Company	476	1,500	Changqing (Shaanxi-Inner Mongolia)	2005
Jingbian County - Xian:	488	1,000	Changqing	1997
		Under Construction		
Third West-to-East: CNPC	5220	25,000	Central Asia	2015
Burma-Yunnan-Guangxi	934 (in-China portion)	12,000	Burma	2013

Source: Xinhuanet (2001); China Central Government Website (2006); Yangtze Evening News (2005); China Oil and Gas Pipeline Website (2004); China Oil Network Website (2005); General Electric Company (2008); China Daily (2005)

Import Gas Pipelines

In recognition of the limitations of domestic gas fields, the CNPC made moves to secure international pipeline gas from the following sources:

(1) Central Asia.

After complex negotiations in which the governments concerned played a major role, the CNPC signed agreements with relevant counterparties in 2007-2008 to import 30 billion cubic meters of Turkmenistan gas per year to China over a 30-year period, including 13 billion from concessions it would develop itself along the Turkmenistan-Uzbekistan border, and 17 billion directly from the Turkmen producer Turkmengazi. With financing from Chinese state banks The agreement also included the construction of two side-by-side 15 billion cubic meter per year, 1818 km pipelines through Uzbekistan and Kazakhstan to the Xinjiang border in cooperation with the local governments and pipeline authorities, and.

As work on these facilities progressed from 2008-2010, the CNPC undertook in parallel the construction of a second West-to-East trunk pipeline running 4,945 kilometers to Guangzhou, with eight branch pipelines totaling 3,849 to destinations throughout central and eastern China to transport the Central Asian gas to Chinese customers. Guangdong Province, which began receiving gas near the end of 2011, will reportedly consume 10 billion cubic meters; a branch from Jiangxi Province will supply another 10 billion to the lower Yangtze Valley provinces, primarily Zhejiang. The entire project, which has been reported to cost the equivalent of $20 billion, has been commissioned in stages starting from 2010 and will achieve full capacity by 2013-2014. Shipments in 2011 had already reached 13 billion cubic meters, over 40 percent of potential throughput.

The CNPC is following up this massive Central Asian project with a second one of comparable size involving: (1) Gas purchase agreements with suppliers in Uzbekistan and Kazakhstan, as well as Turkmenistan totaling 25 billion cubic meters; (2) Addition of a third central Asian pipeline of 25 billion cubic meter capacity to transport this gas to the Xinjiang border; and (3) Construction of a third West-to-East pipeline which will parallel the second one for much of the route, but which terminates in Fujian Province. Construction work began in 2012, and is projected to be completed in the 2014-2016 time-frame.

(2) Burma

In December 2008, CNPC signed a series of agreements with the Burmese government and a Daewoo gas production consortium to build a 793 km, 12 billion cubic meter capacity pipeline to transport gas from two offshore blocks in the Bay of Bengal across Burma to the Chinese border. The gas will feed a new 934 km pipeline from the border through Yunnan, Guizhou and Guangxi Provinces in Southwest, terminating in the Guangxi Provincial capital Nanning. Construction of the Burma portion began in 2010, and the entire project is anticipated to come into operation in 2013-2014.

The Second West-to-East pipeline and its major branches are being connected to the first West-to-East pipeline in at least three locations. Another branch line from the second West-to-East pipeline runs from Ningxia Province to the Changqing gas fields of Inner Mongolia, connecting there with the pipelines to Beijing. An additional line from Ningxia is planned to connect the second and third West-to-East pipelines to Chongqing, the Sichuan gas fields, and the Burma-China pipeline. Finally, the Burma-China pipeline will link to the Nanning, Guangxi terminus of the second West-to-East pipeline.

The new pipelines described above will bring a total of over 65 billion cubic meters of foreign pipeline gas into China by 2015-2016. Their completion, furthermore, will mark the inauguration of a true, if rudimentary interconnected pipeline network extending into all of China's provinces except Tibet.

This network will give the CNPC more flexibility for gas dispatch than it has ever enjoyed in the past, but it is unlikely to provide close to enough gas for all potential civil, commercial, and industrial consumers in these cities. Shenzhen will by itself absorb a reported four billion of the 10 billion cubic meters of second West-to-East pipeline gas allocated to Guangdong.

5.1.3.2 Imported LNG

From 2000 the central government committed to import LNG from outside of China to inaugurate natural gas usage in the southern coastal provinces of Guangdong and Fujian, and to augment gas supply in other coastal areas. By 2011, LNG imported into large terminals built by CNOOC and CNPC in Guangdong, Fujian, Shanghai, and Jiangsu already accounted for 17.8 billion cubic meters equivalent, or 14.6 percent of national natural gas consumption (**Table 56**). The majority of imported LNG is gasified and fed into newly built (in the case of Guangdong and Fujian) or existing pipeline systems for shipment to municipal and industrial customers. A portion is shipped via small tanker truck to customers without direct pipeline access.

By 2015, 12 terminals with aggregate capacity of 40 million tonnes (57 billion cubic meter equivalent) will be in operation (**Table 57**). To supply these terminals, Chinese distributors have entered into long term purchase agreements with producers from Australia, Indonesia, Malaysia, and Qatar to supply a total of 31 million tonnes (45 billion cubic meters) per year. This volume, when added to the projected 67 billion cubic meters of pipeline imports from Central Asia and Burma, will add a total of 95 billion cubic meters of supply, more than one third of projected total gas consumption in 2015 and in line with the target in the Twelfth Five-year Plan.

TABLE 56: LNG SUPPLY CONTRACTS

Supplier	Buyer	Supply Period	Volume (million tpy)	Destination
Australia Northwest Shelf Project	CNOOC	2006-2031	3.7	Shenzhen Dapeng Terminal
Indonesia Tangguh Project	CNOOC	2009-2034	2.6	Fujian terminal
Petronas (Malaysia)	CNOOC	2009-2034	1.1 (2009-2011) 3 (2012-2034)	Shanghai
Qatargas II and III	CNOOC	June 2008 (2009-2034)	2	Shenzhen, Fujian, Ningbo
Qatargas IV Project	CNPC	2011-2036	3	Jiangsu, Dalian, Hebei Tangshan
Total portfolio (France)	CNOOC	2010-?	1	CNOOC sites

Shell: Australia Gorgon and other locations	CNPC	2011-2031	2	Jiangsu, Dalian, Tangshan
GDF Suez (portfolio)	CNOOC	2013-2017	2.6	Various
Qatargas	CNOOC	2013	3	
Exxon Mobil: Gorgon Project Australia	CNPC	2014-2034	2.25	Jiangsu, Dalian, Tangshan
Australia Queensland Curtis Project	CNOOC	2014-2034	3.6	Various
Exxon Mobile Papua New Guinea	Sinopec	2013	2	Qingdao, Shandong

Source: Xinhua January 23, 2007; Shell October 4, 2008; Xinhua November 25, 2008; China Daily June 25, 2008

TABLE 57: LNG IMPORT TERMINAL PROJECTS 2006-2015

Location and Sponsor	Capacity (million tpy)	Status	Gas Use
Shenzhen Dapeng (CNOOC)	3.7 (expanded to 6.8)	Onstream 2006	Five power plants (70 percent); municipal distribution in Guangzhou, Shenzhen, Dongguan, Foshan (30 percent)
Fujian (CNOOC)	2.6	Onstream 2008	Three large power plants (65 percent); municipal distribution in 5 cities (35 percent)
Shanghai (CNOOC)	3	Onstream 2009	NA
Rudong, Jiangsu (CNPC)	3.5	On-stream 2011	Peaking gas supply to Jiangsu-Shanghai area; interconnection to first West-to-East pipeline; tanker truck shipments
Dalian, Liaoning (CNPC)	3	Onstream 2012,	To be connected with a new Liaoning Province pipeline network and Qinghuangdao-Shenyang pipeline
Ningbo, Zhejiang (CNOOC)	3	Construction On-stream 2012	NA
Zhuhai, Guangdong (CNOOC)	3.5	Civil construction On-stream 2013	NA
Jieyang, Guangdong (CNOOC)	2	Civil construction On-stream 2013	For the eastern Guangdong area

Location and Sponsor	Capacity (million tpy)	Status	Gas Use
Yangpu, Hainan (CNOOC)	3	Construction On-stream 2014	NA
Tangshan, Hebei (CNPC PetroChina)	3	Construction On-stream 2013	NA
Qingdao, Shandong (Sinopec)	3	Civil Construction On-stream 2013	NA
Shenzhen Diefu (CNOOC)	4	Civil construction On-stream 2015	NA

Source: Xinhua (2007); PetroChina (2008); Bloomberg (2008); China Daily (2008); China Daily (2009) ChinaMining.org (2008); Guangzhou Daily (2010); Hainan Municipal Website (2011); Peninsula Daily News (2011); Chinagate (2009); China Development Gateway Network (2009); China Central Television (2010); ChinaPower (2006); People's Daily Online (2006); Xinhuanet (2004); WhatsonXiamen (2008)

5.1.3.3 Small-Scale Domestic LNG

A proliferation of small-scale LNG plants using on-land, domestic fuel sources play a distinctive spot supplier role in China's natural gas industry. At least a dozen such plants using both imported and domestic technology, with total capacity of over one billion cubic meters, have been built from 2005-2012.

The output of these facilities is shipped by tanker truck to faraway consumers around the country. It has proven indispensable for distribution companies in large and medium-sized cities not connected to pipeline gas that would otherwise have no source of product, and to connected utilities that receive insufficient allocations for their existing customers.

The majority of these plants use gas from nearby conventional gas fields as a feedstock; some use alternative fuels such as CBM, CMM, coke oven gas, or even coal in one case. Manufacturers include downstream gas distribution companies wishing to lock in supply, companies affiliated with local governments near the gas fields that have received gas allocations through political connections, and affiliates of the major upstream oil and gas companies themselves.

Local LNG has been attractive to the manufacturers because, unlike pipeline gas or LNG from the big import terminals discussed above, sales prices are not regulated by the central government. Distribution companies, particularly in richer provinces such as Guangdong, that have not been connected to pipelines have proven willing to offer prices well above that for pipeline gas; their final customers who have no history or vested interest with cheaper pipeline gas have proven willing to absorb the cost.

The NDRC looks skeptically at what would appear to be an irrational use of resources that could be shipped more efficiently through pipelines; its 2007 white paper on natural gas utilization policy stated that "It is clearly forbidden for gas from large and medium-sized fields to be used for the manufacture of LNG". But while this directive has undoubtedly reduced the number of such plants under construction, it does not appear to have eliminated them completely. The "no build" policy, furthermore, does not apply to domestic LNG plants using nonconventional fuels such as CBM and CMM.

5.1.4 China's Natural Gas Prices

5.1.4.1 Policy and Reforms

Through 2012, the NDRC has strictly regulated the production and pipeline distribution prices charged by the major oil and gas companies. It has striven, not always successfully, to simultaneously: (1) cover the oil companies' production and transmission costs with allowance for a modest rate of return and; (2) fix prices at a level that the major consumers, including politically important consumers such as chemical fertilizer plants, can absorb.

The result has been a complex, multi-tiered pricing system with different wholesale prices charged to different categories of end-user. Prices have typically been adjusted upwards by margins of 25-50 percent about every three years as producers' margins come under pressure.

The NDRC has been considering two not necessarily compatible strategies for reforming upstream pricing: (1) letting the market determine natural gas prices by opening up the upstream sector to more competition, maintaining the competition that already exists in the downstream distribution sector, and regulating pipeline prices as a natural monopoly to which all upstream and downstream players enjoy equal access on equal terms; and (2) capturing the full economic value of natural gas and encouraging conservation by linking its prices to those of competing fuels such as liquefied petroleum gas (LPG), fuel oil, and gasoline. In late 2011 NDRC issued a set of experimental regulations for the southern provinces of Guangdong and Guangxi that combined elements of both approaches with some from the existing system.

Under these regulations, wholesale citygate prices[4] for onshore domestic or imported pipeline gas were fixed at 2.74 and 2.75 CNY per cubic meter, respectively, for Guangdong and Guangxi. These price levels were said to be based on a formula, fixing them at 90 percent on a heating value basis of a basket that is weighted 60 percent for fuel oil and 40 percent for LPG imported to Shanghai in 2010 ($80 USD per barrel of crude oil basis). The price is then adjusted for the shipping route and costs for the main source of gas and taking into consideration the level of economic development in the provinces.

According to the regulations, these prices should be adjusted at regular intervals according to changes in the prices of the fuel oil and LPG basket, but in the interests of stability would be kept at their initial levels "until the price reform is extended to the rest of the country" (NDRC, 2011.5). The many questions this statement left unanswered included how to compensate the CNPC for the losses incurred shipped to Guangdong from Central Asia.

In a nod to competition, the pipeline citygate prices were fixed as ceilings, with consumers free to try to negotiate lower prices with shippers without restriction. The regulations also indicated that as a matter of principle, non-conventional gas such as shale gas, CBM and CMM should be set freely, but that the referenced citygate prices would apply for the time being to any non-conventional gas shipped through the major pipelines to Guangdong and Guangxi.

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[4] Transfer prices from the national upstream pipeline companies to their customers, including provincial pipeline companies, municipal distribution companies, and certain large industrial enterprises

5.1.4.2 Domestic Wellhead, Pipeline, and Citygate Prices, 2012

Following in **Table 58** and **Table 59** are wellhead prices, pipeline transmission prices, and reported or estimated pipeline citygate prices as of August 2012. The lower boundary of the range for each price point represents the government "baseline" price, and the upper boundary represents the maximum allowable 10 percent over benchmark. It can be seen that delivered prices from domestic gas fields to major cities range for the most part between 1.5 and 2.4 CNY per cubic meter.

TABLE 58: WELL-HEAD NATURAL GAS PRICES, 2012

	Chemical Fertilizer	Direct Supply to Industry	Municipal Distribution Company to Industry	Municipal Distribution Company (Civil Use)
	CNY per m^3			
	USD/mmbtu			
Sichuan Oil and Gas field (local)	0.92-1.012	1.505-1.656	1.55-1.705	1.15-1.265
	4.02	6.58	6.78	5.03
Changqing Oilfield	0.94-1.034	1.355-1.491	1.4-1.54	1-1.1
	4.12-4.53	5.93-6.53	6.12-6.73	4.37- 4.81
Qinghai Oilfield	0.8 -0.979	1.29-1.419	1.29-1.419	0.89-0.979
	3.89-4.23	5.64 -6.20	5.64-6.20	3.89-4.28
Xinjiang Oilfields (local)	0.79-0.869	1.215-1.337	1.19-1.309	0.79-0.869
	3.45-3.80	5.31-5.841	5.20-5.72	3.45-3.80
Xinjiang: West-to-East Pipeline	0.79-0.869	1.215-1.337	1.19-1.309	0.79-0.869
	3.45-3.80	5.31-5.841	5.20-5.72	3.45-3.80
Sichuan: Chongqing to Wuhan Pipeline	1.141-1.256	1.541-1.70	1.541-1.70	1.141-1.256
	4.99-5.49	6.74-7.41	6.74-7.41	4.995.49
Changqing: Shaanxi to Beijing Pipeline	1.06-1.166	1.46-1.606	1.46-1.606	1.06-1.166
	4.635.09	6.38-7.02	6.38-7.02	4.63-5.09
Sichuan to Shanghai Pipeline	1.51-1.661			
	6.60-7.26			

Source: NDRC (2010.2) Note: All prices are inclusive of 13 percent VAT. Assumes 6.35 CNY per USD and 38,000 kJ/m^3 of gas.

TABLE 59: DOMESTIC PIPELINE GAS CITYGATE PRICES IN REPRESENTATIVE CHINESE CITIES, 2012

	Gas Source	Pipeline Transmission Price (CNY/ m^3)	End User Category	Citygate Price	
				CNY/m^3	USD/mmbtu
Beijing	Changqing gas field via Jingbian-Beijing Pipeline	0.42	Industry (except fertilizer) Civil Use	2.026 8.87	1.586 6.95

	Gas Source	Pipeline Transmission Price (CNY/ m³)	End User Category	Citygate Price	
				CNY/m³	USD/mmbtu
Shanghai	Xinjiang via First West-to-East Pipeline	0.98	Industry Civil Use	2.30 10.07	1.85 8.10
Shanghai	Sichuan via Sinopec Chongqing-Shanghai pipeline	0.84	All	2.38 10.42	1.86 8.12
Wuhan, Hubei Province	Sichuan via Sinopec Chongqing-Shanghai Pipeline	0.54	All	2.08 9.11	1.62 7.11
Anhui Province†	Xinjiang via First West-to-East Pipeline	0.75	Industry Civil Use	2.07 9.06	1.62 7.09
Chongqing	Sichuan gas fields	0.12-0.13	Industry Civil Use	1.8	1.4

†Anhui prices include only transfer prices to provincial pipeline company, not the provincial pipeline company's own charges.

5.1.4.3 Imported Pipeline Gas Prices

Gas imports have clearly put pressure on the domestic gas price structure. While the purchase price for gas imported from Turkmenistan via the Central Asian pipeline has never been publicly released, numerous Chinese media reports indicate that it is adjusted at regular intervals according to international oil prices, and that the delivered price to the Chinese border is 2.10-2.2 CNY per cubic meter at a benchmark oil price of $60 USD per barrel. This benchmark was 33-100 percent higher than wellhead prices from domestic Chinese fields as of third quarter 2012; the real differential was still higher given international oil futures prices of around $95 USD per barrel.

Through the third quarter of 2012, the CNPC was not allowed to pass these costs through to its gas offtakers, suffering significant losses that were partly offset by VAT rebates from the government. The CNPC reported to have reached agreement with the various provinces on a new price structure for Central Asian gas in preparation for the formal declaration of pipeline completion towards the end of 2012. It can be estimated, based on the reported 2.15 CNY benchmark price to the border, and on the pipeline transmission prices for the first West-to-East pipeline shipping domestic gas, that the delivered price for Central Asian gas to Eastern and Southern Coastal load centers would have to be in excess of 3 CNY per cubic meter to make the CNPC whole.

According to one media report, CNPC will pay $7.73 USD per mmbtu for Burmese offshore gas landed in Burma, equivalent to about 1.75 CNY per cubic meter indexed to oil. Given shorter pipeline distances compared to the West-to-East lines from Xinjiang, it can be estimated that the wholesale price charged to load centers in Southwest China would be somewhere in between that for domestic pipeline gas and for Central Asian gas, perhaps 2.5 CNY per cubic meter.

5.1.4.4 Imported LNG

Import LNG prices signed by the CNOOC for the initial import terminals in Shenzhen and Fujian with suppliers from Australia and Indonesia in 2002-2003 ($2.85 and $3.80 USD per mmbtu, based on then-prevailing prices of about $20-25 USD per barrel) were compatible with China's domestic oilfield wholesale prices of 2012. The ex-terminal prices charged for this LNG when the plants came on-stream in 2006 and 2008 appears to have been in the vicinity of 1.50 CNY per cubic meter.

Prices for contracts signed with Qatari and other suppliers starting from 2008, indexed to oil prices 3-5 times higher than in 2002-2003, have put considerably more pressure on China's gas cost structure. Press and industry insider reports suggest that ex-terminal sales prices to final offtakers are order of magnitude 3 CNY per cubic meter or slightly higher.

5.1.4.5 Domestically Manufactured LNG Prices

As noted above, the sales prices of the small-scale domestic LNG plants is unregulated, and determined strictly by market forces. Prices of 3-4 CNY per cubic meter (including transport) have been obtained for regions such as Nanning, Guangxi Province, or small and medium-size cities in Guangdong Province which have not enjoyed access to pipeline gas. The government-fixed prices for Central Asian gas will likely determine what the LNG plants will be able to charge in the longer term. If the government allows the CNPC to recover its costs for the Central Asian gas, a level of at least 3 CNY per cubic meter could probably be maintained unless there is a glut of supply.

5.1.4.6 Retail Prices

The retail prices charged by gas distribution companies are regulated by municipal governments or, in certain provinces with low consumption levels, by provincial governments. The guiding principle is to allow distribution companies a modest return of about eight percent.

The central government charges lower wholesale prices for pipeline gas to be sold for civil use (**Table 58** and **Table 59**). Philosophies differ regarding retail pricing differentials, with most utilities fixing the industrial cost higher to subsidize residential consumers, while others try to recover distribution costs from residential consumers, which are higher than for their industrial counterparts. National regulations have required municipalities to hold public meetings prior to increases in residential use prices, which creates some pressure to keep them in check; industrial prices have not been subjected to the public meetings requirement.

Utilities are allowed to automatically pass through published wholesale price increases for domestic conventional natural gas to industrial customers. Certain utilities such as Chongqing now do so for civil use customers as well, and this could be the trend for the future throughout the country.

There are significant regional variations based on proximity to gas. In cities connected to domestic pipeline gas, prices to residential users were in the range of 2.0 to 2.5 CNY per cubic meter in 2012. Prices have been higher in the major cities of Southern coastal Guangdong province, whose main source of supply has been imported LNG.

Retail prices for gas of 4-5 CNY per cubic meter have been charged in municipalities unconnected to pipeline gas. These municipalities have been totally reliant on domestic small-scale LNG plants, which are allowed to charge market wholesale prices. As pipeline gas gradually arrives, prices in these locations can be expected to drop somewhat, although they will most likely be significantly higher than in cities with a longer history of connection to the long-distance pipelines.

Table 60 below shows regulated retail prices charged in a sample of cities as of mid-2012. Many cities in the Yangtze Valley, such as Shanghai, were preparing to increase prices to reflect the higher cost of Central Asian gas.

TABLE 60: NATURAL GAS RETAIL PRICES IN SELECTED CHINESE CITIES, THIRD QUARTER 2012 (CNY/M^3)

	Residential	Industrial	Gas Source	Timing of most recent price increase
Beijing	2.05	2.84	Changqing Gas field	2010 (industrial) 2006 (residential)
Shanghai	2.5	3.39 -4.19	Pipeline from Xinjiang, Shanghai, imported LNG;	2010 (industrial) 2008 (residential)
Chongqing	1.72	2.24	Nearby Sichuan Gas fields	2010
Guangzhou	3.45	2.21 (Direct sale by pipeline company at high pressure) 4.85 (sale by distribution company at lower pressure)	Import LNG, Shenzhen terminal; Central Asian gas (2012)	2007 (residential) 2009 (industrial)
Nanning, Guangxi	4.1	NA	Domestic LNG; Central Asian pipeline gas as of 2012-2013	2011

5.1.5 Unconventional Gas: CBM and CMM

CBM and CMM have gradually evolved from a pure mine safety concern to a significant component of natural gas development in the government's Twelfth Five-year Plan. The degree of actual integration of CMM into the natural gas economy will depend on continuing demand-side pressures, the favorability of the regulatory environment, and the quality of management of CMM operation by the mines themselves.

5.1.5.1 CBM and CMM in the Twelfth Five-year Plan

The government's draft Twelfth Five-year Plan for natural gas explicitly includes CBM for the first time, projecting consumption to rise to 20 billion cubic meters by 2015, or about 8 percent of the total. The NEA's Twelfth Five-year Plan for CBM and CMM is even more ambitious, calling for total production to rise to 30 billion cubic meters by 2015 – 16 billion for CBM and 14 billion for CMM. The utilization rate for pumped CMM is called to rise to 8.4 billion cubic meters from the 2010 level (NEA, 2011).

Of the 16 billion cubic meters of CBM captured through surface drilling, the NEA projects that 10 billion should come from the Qinshui Basin, 5.4 billion from Ordos Basin, with the remaining 600 million coming from smaller developments from other provinces. Significantly, the plan also calls for the construction of 13 pipelines with total length of over 2000 km and 12 billion cubic meters per year total shipping capacity, signaling a significantly increased effort to integrate CBM into the largest natural gas economy.

These efforts were already underway in the latter part of the 2000s, with the construction by CNPC of a one billion cubic meter per year CBM processing facility in the Qinshui basin with the intent to inject its own and third-party CBM into the nearby first West-to-East pipeline. The government of Shanxi, the location of most of the CBM development (and an area which has received only limited allocations of pipelined conventional gas) is spearheading a particularly aggressive in-province mixed natural gas-CBM pipeline program including, among other facilities:

- Two billion cubic meter per year 460 km line from Changzhi in the Southeast to the Provincial Capital Taiyuan, completed in 2012, which will ship a mixture of Qinshui CBM and conventional gas from Sinopec's Shaanxi-Shandong line.
- Two lines totaling over 300 km with capacity to ship about one billion cubic meters from Ordos and Gujiao areas in the western part of the province to Taiyuan.
- A 471 km line from the Linxian area of the Ordos CBM basin south to Linhe completed in 2012, which will be extended to the northwest in order to accept gas from the third Shaanxi-Bejing pipeline.
- A one billion cubic meter per year, 50 km transprovincial pipeline from Qinshui to Bo'ai in Henan Province, completed in late 2010.

Shanxi political leaders anticipate that CBM could amount to as much as 75 percent of Taiyuan's five billion cubic meters of planned natural gas consumption in 2015.

Producers, consumers, and middlemen have also undertaken three small LNG facilities to transport Qinshui CBM to more distant markets by tanker truck, including:

- A 40 million cubic meter plant owned by the national gas distribution Xin'ao, completed in 2009.
- Two plants totaling 300 million cubic meters per year owned jointly by the Jincheng Coal Mining Group and Hong Kong Gas, Phase I completedin 2009, and Phase II under construction in 2012.
- A 330 million plant owned by the Shanxi Energy Industry Group, a coal and gas transport company.

The Twelfth Five-year Plan for CBM and CMM calls for CMM to be used primarily as a local fuel, with the number of residential users to approximately double to about 3.3 million households between 2010 and 2015, and power generation capacity to quadruple to 2850 MW as overall CMM utilization rises by about 5.5 billion cubic meters.

It will be necessary to improve CMM extraction practices to raise the average methane content of the CMM given the difficulties and expense of utilizing low-concentration methane. Of the approximately 7.5 billion cubic meters of CMM extracted in 2010, a significant majority was less than 30 percent concentration.

A series of regulations put forward by the NEA and the China Ministry of Environmental Protection (MEP) attempt to deal with the problem. But at least through mid-2012, there was anecdotal evidence that an MEP-issued regulation in 2008 requiring operators of CMM drainage systems with greater than 30 percent methane concentration to use or flare the gas was creating a perverse incentive in some areas to maintain gas concentrations below 30 percent, ignoring best practices and safety standards.

The focus on local consumption of CMM poses additional challenges, as many of the coal mines recovering CMM have exhausted the possibilities for burning the CMM to generate power for their own use, or supplying CMM to customers in the immediate vicinity of the mines. Only a few local governments such as Jincheng, a municipality of approximately two million people in the Qinshui basin area, have mobilized to invest in region-wide CMM distribution infrastructure.

Jincheng has advantages that other localities do not necessarily share, including the ability to mix higher methane-content CBM with its CMM, and a supportive provincial government, which has granted CMM producers an additional 0.3 CNY per cubic meter rebate for CMM sales for civil and industrial use on top of the 0.2 CNY offered by the national government. Despite the booming demand for natural gas, municipalities such as Chongqing have not found it cost-effective to construct the medium-distance pipelines necessary to transport unprocessed CMM from large producers such as Songzao into the city proper in view of the gathering, pipeline investment, and processing costs.

The government's Twelfth Five-year Plan for CBM and CMM addresses the barriers to the further popularization of CMM in general terms, acknowledging the unfavorable economics of many CMM utilization projects, the difficulties winning power grid company acceptance of the existing regulations requiring them to accept CMM-generated power at premium prices, and the need for stronger government incentives to promote CMM utilization. Follow-through on removal of these barriers will be key to enforcement of the power dispatch and CMM pricing policies and achieve the power generation targets.

As with CBM, the purification and liquefaction of CMM offers a potential solution to the market barrier problems. Technologies to remove impurities of CMM at low temperature have been proven outside of China, and are under development in China itself; no extra step is required to liquefy once purification has taken place.

While it would most likely not be economic to sell the product to the petroleum pipeline companies given the domestic gas pipeline transmission pricing structure, transportation by tanker truck would allow the CMM plants to sell directly to near or distant distribution companies. They would have the freedom to seek markets in the relatively wealthy southern coastal areas, which depend almost exclusively on imported gas with which CMM is likely to be more cost competitive (3-3.5 CNY per cubic meter delivered to citygate), and which have shown a willingness to absorb higher prices.

Given the modest size of the plants and the variability of CMM flows, they would likely sell primarily into the spot or peaking markets. If liquefied CMM accounted for only a small proportion of supply in a particular region, even distribution companies in less wealthy areas might also be able to absorb its higher cost relative to domestic pipeline gas.

Liquefied CMM would also likely be cost-competitive with methane from coal to natural gas plants transported by pipeline, which the government is considering as part of the Twelfth Five-year Plan for natural gas.

Large-scale development of shale gas, on the other hand, could lower the cost structure of the national gas industry as it has in the United States, working against the interests of CMM producers. Given the time that will be required to develop shale gas expertise, this is likely to be a long-term rather than a medium-term issue. In general, the economics of purified and liquefied CMM should be attractive under conditions where overall supply continues to be tight, and imported gas is a significant component of the overall natural gas sales base.

While many coal mining companies have considered the LNG option for utilization of their CMM, most have hesitated to move ahead in view of the high up-front cost relative to other options such as small distributed power plants, and the lack of reference CMM LNG units in China. As of mid-2012, only small demonstration facilities constructed by Chinese purification technology developers were in operation.

The Twelfth Five-year Plan listed calls for development of CMM purification/LNG plants to an appropriate degree. The first industrial-scale facility, a 100 million cubic meters per year plant (100 percent methane basis, with as-is CMM at approximately 40 percent) developed by the Chongqing Energy Investment Group's Songzao Coal and Electricity Corporation was under construction, due in operation in 2013. The success of this flagship project would encourage the development of a number of additional facilities in coal mining areas that produced a sufficiently high volume of medium-concentration CMM.

5.1.5.2 CBM/CMM Development Through 2014

Spurred by the favorable experience of the United States with CBM, the Chinese government launched a joint CBM exploitation program with foreign companies in the 1990s, with modest results (**Table 61**). CBM production on an appreciable scale only began from about 2005, with 2010 output rising to 1.5 billion cubic meters, primarily from Chinese coal companies evacuating the CBM in advance of mining, and from Chinese petroleum companies rather than from Chinese-foreign joint ventures. The Ministry of Land Resources announced in January 2014 that 2013 production was 3 billion cubic meters (Andrews-Speed and Len, 2014). While goals set by the 12th Five year plan were to increase annual production of CBM up to 16 billion cubic meters by 2015 (EIA , 2104) production was up by 9% year-on-year for the first three quarters in 2014 and reached 12.6 billion cubic meters (World Coal, 2014). CBM from non-mine related drilling and production was 2.7 billion cubic meters while 9.9 billion was extracted from coal mines (World Coal, 2014). Almost all of the development has taken place in the major coal basins with the most favorable natural conditions: the Qinshui basin in Southeast Shanxi Province, a major coal producing area, and the Hedong/Ordos basin in the border region of western Shanxi, Shaanxi, and Inner Mongolia. Through 2010, CBM was used either as a household or industrial fuel in the vicinity of these major basins. Until approximately 2010/2011, gas was only consumed locally as a household or industrial fuel.

TABLE 61: CBM/CMM RECOVERY AND UTILIZATION IN CHINA (BILLION CUBIC METERS)

	2009	**2010**	**2011**	**2012**	**2013**	**2014**
CMM from Coal Mines (excluding VAM)						
-- Recovery	6,450	7,500	9,200	11,400	12,600	13,120

	2009	2010	2011	2012	2013	2014
-- Utilization	1,930	2,300	3,500	3,500	4,250	4,360
CBM from Surface Wells						
-- Recovery	1,010	1,500	NA	NA	NA	NA
-- Utilization	580	1,200	NA	NA	NA	NA
Total CMM and CBM						
-- Recovery	7,460	NA	NA	NA	NA	NA
-- Utilization	2,420	NA	NA	NA	NA	NA

Source: Huang (2014), NDRC (2010.2), NEA (2011)

The implementation of the CDM platform for carbon credit revenue stimulated increased interest in the utilization of CMM. Soon afterwards, the Chinese central government promulgated its own incentives for CBM and CMM producers, including a 0.20 CNY per cubic meter payment for CMM consumed as a household or industrial fuel, and an approximately 50 percent price premium over coal for power sold to the public grid. The grid companies were directed to provide favorable dispatch to the CMM generators (MOF, 2007; NDRC, 2007.4). As of late 2014, nine projects have been registered and are undergoing validation for registration in a voluntary emissions reduction program created in 2012 by the NDRC. This program was created by NDRC promulgating Temporary Rules for Voluntary Green House Gas Emissions Reduction Trading Management in June 2012. (Huang, 2014)

As of September of 2014, 92 CMM projects have been prepared for the CDM and approved by the central government; of those, 58 projects have been registered with the United Nations Framework Convention on Climate Change (UNFCCC). Certified emission reductions (CER) have been issued from 30 of these projects (Huang, 2014). Coal mining companies installed a reported aggregate 750 MW of distributed power plants to burn CMM (including the 120 MW plant at the Jincheng Coal Mining Company in the Qinshui Basin, the world's largest CMM power plant), and the number of CMM household and industrial customers rose to 1.89 million (NEA, 2011). CMM utilization lagged far behind extraction given the limitations of local utilization infrastructure, and the failure of CMM to penetrate the larger natural gas market (**Table 61**). The incentive program for CMM power plant utilization proved particularly difficult to implement due to resistance from power grid companies. The companies were uneager to manage the complexities of dispatching the fluctuating output of small plants, and lacked a policy mechanism to pass the premiums through to consumers.

In September of 2013, the State Council published a guideline for further acceleration of CBM/CMM exploitation and utilization (Huang, 2014). This guideline aims to:

- Increase funding to support development;
- Increase indirect economic and financial incentives;
- Encourage investment from the private sector;
- Develop a market driven pricing mechanism; and
- Further encourage the use of CMM for fuel in power production.

According to an NDRC press release in August 2014, China is poised to take the experience that it has gained with its pilot carbon trading markets located in seven key cities and launch a national trading market. The NDRC has developed national market regulations and has submitted them to the State Council for approval with an opening of the national market sometime in 2016 (Reuter, 2014), and will be situated among several other Asia countries that are in various stages of developing carbon markets. Kazakhstan and South Korea have active markets, while Indonesia, Thailand and Viet Nam are in the planning stages.

The end of 2014 marked the first year of carbon trading in regional markets, and as of January, 2015 a national emission offset registry was opened and the Chinese Certified Emissions Reductions (CCERs) issued from this registry will be tradable among the seven regional markets. This comes as a relief to buyers and sellers who want to trade offsets from one region to another. The price of emissions reductions vary widely from one regional market to another. As an example, a firm can buy emissions reductions for 20 CNY in Guangdong, but the same permit would cost 53 CNY in Beijing. Until there is a unified market in 2016, regional carbon market regulators can exclude any offset type if they determine that the CCERs will not benefit their local market. The unified market will harmonize rules among the seven pilot programs and allow trading countrywide. CCERs are awarded to low carbon projects approved by the NDRC. Presently, they are cheaper than the offsets, which are available in the regional markets and can only be used to cover 5 to 10 percent of the firm's carbon emissions. Spot deliveries of CCERs offered to the Beijing market range from 25 to 30 CNY; however, forward contracts can be purchased for less, in the range of 5 to 20 CNY (Reuters, 2015).

5.1.6 Unconventional Gas: Coal to Gas

In an economy in which natural gas shortages have been projected into the indefinite future and imports account for an increasing market share, the development of coal-to-gas (CTG) technology has attracted interest from coal development companies such as Shenhua, governments of regions with major untapped coal reserves such as Inner Mongolia and Xinjiang, and some gas users and financial investors. Even Sinopec, the smaller of the two major land-based conventional natural gas producers, is reported to be considering the construction of pipelines to transport the output of CTG plants from Xinjiang to the east.

A total of 30-40 projects with aggregate capacity approaching 100 billion cubic meters per year have been proposed. The draft Twelfth Five-year Plan for natural gas submitted by the NEA to the central government for consideration in May 2012 called for annual production of methane from coal to reach 30 billion cubic meters by 2015 (NEA, 2012.1). As of mid-2012, NDRC had only approved four demonstration projects with aggregate capacity of 17.5 billion cubic meter capacity (**Table 62**). The projects are the first reference units for the Chinese technology and equipment suppliers, and their completion has been delayed 2-3 years beyond initial expectations.

TABLE 62: CHINA COAL-TO-GAS PLANTS UNDER CONSTRUCTION, 2012

Plant and Location	Owner	Capacity (m^3)	Projected Completion Date	End-use
Chifeng, Northeast Inner Mongolia	Datang Power Company and Beijing Natural Gas Company	4 billion (3 trains, each 1.3-1.4 billion)	2012-2014	Sent to Beijing and environs through newly constructed pipeline
Fuxin, Liaoning Province	Datang Power Company	4 billion (3 trains of 1.3-1.4 billion)	2012-2014	Shenyang and other Liaoning cities

Plant and Location	Owner	Capacity (m^3)	Projected Completion Date	End-use
Ordos, Inner Mongolia	Inner Mongolia Huineng Energy Company	2 billion	2013	Power plant fuel, liquefaction long-distance shipment
Yili, Xinjiang Autonomous Region	Inner Mongolia Guoqing Energy Company	5 billion (4 trains 1.2-1.3 billion)	2012-2015	Injection into CNPC West-to-East pipelines)

Source: Inner Mongolia Television (2012)

NDRC has on several occasions expressed caution about proceeding quickly pending the formulation of a national CTG development strategy based on full evaluation of technical, economic and environmental issues such as energy conversion efficiency, water resource management, etc. In November of 2011, the NDRC issued "Regulations on Orderly Development of the Coal Chemical Industry" which, among other restrictions, banned the consideration of CTG projects with capacity less than 2 million tonnes per year (NDRC, 2011.4).

As with CBM and CMM, the economic viability of CTG projects will depend on how tight the natural gas market remains both domestically and internationally, and the degree to which the market remains import dependent. One estimate puts production costs at 1.05-2.1 CNY per cubic meter; with estimates of the selling price for the Xinjiang project specifically in the vicinity of 2.9 CNY per cubic meter (Sina News Center, 2012).

As with CBM and CMM, gas distribution utilities may be able to absorb the gas produced from coal more easily when it accounts for only a relatively minor portion of supply. The Chinese energy industry has begun intensive efforts to develop China's considerable shale gas potential in recognition of the breakthroughs in drilling and fracturing technology that has led to the rapid expansion of natural gas production and precipitous natural gas price drop in the United States. A Twelfth Five-year Plan for shale gas put forward by the NEA calls for a thorough nationwide survey and exploration program to identify 50-80 target production areas throughout the country by 2015, with shale gas production reaching 6.5 billion cubic meters in 2015, and expanding dramatically to 60-100 billion cubic meters by 2020 (NEA, 2012.1).

As of mid-2012, CNPC and Sinopec had already drilled dozens of exploratory wells in Southern Sichuan and Northern Yunnan Provinces, Eastern Guizhou Province, and Southern Anhui. CNPC had begun small-scale production in Sichuan, and in May of 2012 signed a production sharing contract with Shell to develop the province's Fushun field.

Sinopec launched its own initial production several months later in the Fuling area of Chongqing, expressing the hope to produce 300-500 million cubic meters in 2011 and one billion in 2012. It was also conducting risk evaluation of structures explored jointly with BP and Chevron in Guizhou.

The central government has made clear that it wants to follow the U.S. model by offering exploration and development rights to a broad range of companies beyond the Chinese state-owned upstream oil and gas companies and the major international oil and gas producers. In addition to CNPC and Sinopec, winners of the first auction for development rights in Chongqing, Sichuan, Guizhou and Hunan in 2011 included the China United CBM and the Henan CBM Development companies, as well as the Shaanxi Province owned Yanchang Petroleum Company. Bidders for the second round in October 2012 which included areas in Hubei, Anhui, Henan and Zhejiang Provinces, in addition to those in the Upper Yangtze Valley, appeared likely to include some privately owned energy companies (Ministry of Land Resources 2011, 2012).

As with other nonconventional gas resources such as CBM and CMM, the NEA's Twelfth Five-year Plan for shale gas calls for the sales price to be set by the market rather than by the government. It also recommends extending to shale gas some of the incentives enjoyed by CBM and CMM producers, such as the 0.2 CNY per cubic meter production subsidy, sales tax rebates, and duty exemption for imported equipment. Some foreign investors question whether the 2015 production target is achievable, in view of the lack of experience and expertise with horizontal drilling and fracturing. At any rate, with the government's desire to develop shale gas, CBM and CMM producers may have positive and negative implications of increased shale gas production to consider. A boom in shale gas development may lead to development of gas processing facilities and pipelines as well as an expanded natural gas market which may benefit CMM; however, an increase in gas supply from shale may drive gas prices down, making unconventional gas resources less economically desirable.

5.2 Anhui

5.2.1 Pipeline Network and Consumption Volumes

Anhui Province has no known gas deposits. It began to use natural gas in limited quantities with the completion in 2004 of CNPC's first West-to-East pipeline, which passes through the northern part of the province in a Northwest to Southeast direction en route from Zhengzhou to Nanjing through Lixin County, Dingyuan County, Bengbu City and Chuzhou City.

The CNPC concurrently built branch pipelines from the Dingyuan County transfer station to the provincial capital in Hefei, and from Nanjing southwest along the southern bank of the Yangtze River through the major steel center of Maanshan to Wuhu City. The Anhui Provincial gas company added a series of smaller branch pipelines from transfer stations on the main line to Fuyang, Huainan, Suzhou, and Huaibei cities, and extended the Wuhu branch further along the Yangtze to Tongling.

Through 2008, the above-mentioned facilities accounted for the entirety of provincial consumption shown in **Table 63** below. The rapid jump in 2009 and 2010 usage represented not only shipments through the West-to-East pipeline, but also the commissioning of the 12 million ton per year Sinopec Sichuan-Shanghai pipeline which runs across southern Anhui from Anqing in the west to Xuancheng in the east near the Zhejiang border.

TABLE 63: ANHUI NATURAL GAS CONSUMPTION, 2007-2012 (MILLION CUBIC METERS)

Consumption	403	717	977	1,254	2,014	2,490

Source: CESY, 2013 p. 96

A branch from Xuancheng to Nanjing passes through some of the same Yangtze River cities as the Nanjing-Wuhu branch of CNPC's West-to-East pipeline. The so-called "North of the River Connector

Line" with approximately 500 million cubic meter capacity is being built north from Anqing to Hefei, where it will link in 2011-2012 to the CNPC branch line, thus creating the beginnings of an integrated network in the province.

5.2.2 Consumption Patterns

Hefei accounted for somewhat over 200 million cubic meters, or about 14 percent of total provincial consumption in 2010. It is unlikely that any other single locality consumed as much as Hefei given constraints on supply and branch pipeline capacity (Anhui News, 2011.1).

Sectorally, industry accounted for the largest share of natural gas use in 2012 (**Figure 33**), but not by as wide a margin as is typical in the rest of the country. Limitations in supply and supporting infrastructure could be a reason for this. The amount used in transportation, which rose from almost nothing in 2007 to over 10 percent of the total in 2009, reflects the rapid popularization of compressed natural gas (CNG) as an inexpensive automotive fuel. The NDRC is demanding that all local authorities in China raise CNG prices to a minimum of 75 percent of gasoline prices in order to discourage overconsumption of natural gas in motor vehicles.

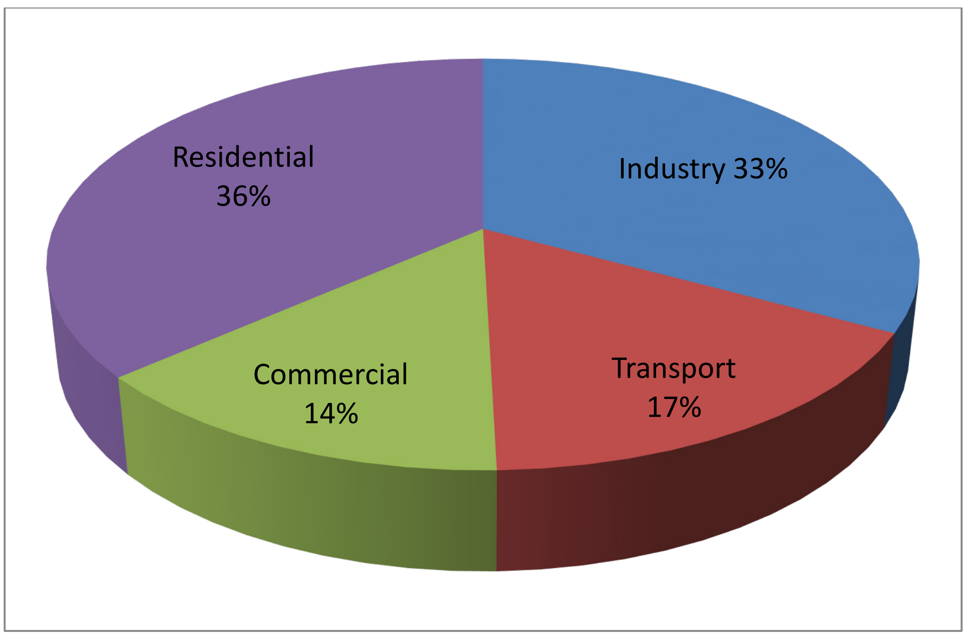

FIGURE 33: ANHUI CONSUMPTION OF NATURAL GAS BY SECTOR, 2012
Source: CESY (2013) p. 203

5.2.3 Future Trends

Gas supply will be the principal constraint on future consumption growth in Anhui. It is reported that the central government has only allocated 800 million out of the 12 billion cubic meter throughput of the Sichuan- Shanghai pipeline to Anhui, and it is unlikely that the figure is much higher than 1.5 billion cubic meters for the first West-to-East pipeline, which suggests a ceiling of perhaps 2.5 billion cubic meters until additional gas sources are developed (China Securities Journal, 2010).

Anhui is not an important destination for Central Asian gas transmitted through the CNPC's Second West-to-East pipeline starting from 2010. One branch of the pipeline passes through Dangshan County in the northernmost sliver of the province, but no infrastructure is being built to get large volumes of Central Asian gas to major potential consumption centers (Anhui News, 2008). The main positive impact of the new pipeline for Anhui will be to put more gas in the increasingly integrated national pipeline network, possibly freeing up some gas from other sources for Anhui.

5.2.4 Pricing

The wholesale pricing for the West-to-East pipeline and Sichual to East pipeline are shown below in **Table 64**.

TABLE 64: WHOLESALE PRICING TO THE MAIN CNPC/SINOPEC TRANSFER STATIONS IN ANHUI (CNY/CUBIC METER)

CNPC Xinjiang gas, first West-to-East Pipeline			
-Residential Use	0.79	0.75	1.54
-Industrial Use	1.19-1.215	0.75	1.965
Sinopec Sichuan gas, "Sichuan to East Pipeline" (all uses)	1.51	0.65	2.16

Source: NDRC 2003; NDRC 2009.1; NDRC 2010.2

5.2.5 CMM Market and End-Use Options

SDIC-Xinji Energy has evaluated the villages close to the Liuzhuang mine but does not consider any to be viable end-users for CMM produced at the mine. Currently, these villages utilize either agricultural waste (straw) or waste coal for heating. The coal also tends to be low-quality coal supplies that are mined locally but not considered viable for transport outside the Liuzhuang area due to poor quality. This waste coal is abundant and quite inexpensive. Liuzhuang CMM would need to be sold at an extremely low price to displace this waste coal, certainly much lower than its alternative value for more profitable utilization approaches, such as power generation.

According to the Huainan government, Huainan Municipality as a whole consumes 120,000 cubic meters of natural gas per day, or approximately 44 million cubic meters per year. Only 180,000 of the city's over one million urban residents are connected to gas (one third of these 180,000 burn coal mine methane), and there are only 6 industrial enterprises burning natural gas, so there is obviously potential for wider use (HMFA, 2011).

Given the limits of the small 17.4 km pipeline connecting CNPC's West-to-East trunkline with Huainan, this suggests that there should in principle be demand for SDIC-Xinji's gas in Huainan generally, beyond the immediate mining area. The mine's ability to either connect to the Huainan local gas distribution network or to sell LNG to an unloading terminal will depend on the local gas company's logistical ability to construct the necessary infrastructure, which cannot be taken for granted in view of the fact that the utility is losing money.

Considering the limitations in natural gas supply to Anhui as a whole, there should certainly be demand for Huainan's purified CMM in other cities in Anhui, if not in Huainan. The mine's capability to sell, however, will undoubtedly depend on the price it charges.

As noted above in **Table 64**, the wholesale prices charged by the local gas distribution companies to CNPC and Sinopec range from 1.54 CNY per cubic meter for Xinjiang gas used as residential fuel (as in Huainan) to 1.965 CNY per cubic meter for Xinjiang gas used for industry to 2.16 CNY per cubic meter for Sinopec Sichuan gas for all usages (inclusive of tax).

Unless the shortages of gas in Anhui become so acute that local governments become willing to pay higher market prices, 2.16 CNY per cubic meter per the Sinopec Sichuan gas wholesale cost is a reasonable reference price for Huainan gas in the Anhui market. Despite the high transport costs, Anhui coal mines might be able to earn a higher return by sending LNG to markets in areas such as Guangdong in southern China where local wholesale prices are 3 CNY per cubic meter or higher.

5.3 Chongqing

Chongqing has one of the oldest and best-developed natural gas distribution infrastructures in China due to its proximity to the Sichuan gas fields. Its total natural gas consumption grew at about 8.5 percent per year to an estimated 5.8 billion cubic meters from 2005-2011, putting it in the top four provincial-level consumers on a per capita basis. The sectoral breakdown of consumption is comparable to the rest of China, with industry accounting for about three quarters of the total, and residential/commercial for about 20-25 percent (**Table 65**).

The use of CNG for the automotive sector, which has a 40 year history, is higher than in other regions in China. Virtually all buses and taxis in the core urban areas run on CNG.

TABLE 65: CHONGQING GAS CONSUMPTION (MILLION CUBIC METERS)

	2004	2005	2006	2007	2008	2009	2010	2011
Chongqing Gas Group	860	965	1250	1482	1700	1724	1869	1970
-- Industrial	168	207	296	346	406	543	618	668
-- Residential	236	262	341	371	421	564	586	656
-- Commercial	37	51	78	100	131	170	201	221
-- Automotive CNG	101	142	174	240	245	356	360	340
--Collective" (public)	NA	NA	NA	45	NA	90	98	85
Direct Purchase by Industry/ Other Distribution Companies	2174	2585	NA	3018	3175	3223	3494 (est.)	3600 (est.)
Total	3034	3550	4005	4353	4875	4947	5363 (est.)	5600 (est)

Source: CESY (2010), p. 90; Chongqing Gas Group, Chongqing Energy Investment Company; Chongqing Gas Group Prospectus (2012)

The Chongqing Gas Group, a subsidiary of CQEIG, has the franchise for gas distribution in the core Chongqing metropolitan area, as well as in a number of the outlying counties and cities, and has accounted for approximately one third of Chongqing's gas sales. Most of the remainder is purchased directly from the upstream suppliers by large industrial enterprises, with the rest going to smaller distribution companies in some of the outlying areas (including companies owned by CNPC itself). Supply has been the most important constraint to more rapid growth in consumption. The municipal government estimates that Chongqing could absorb 15 billion cubic meters by 2015, two and one half times 2011 usage, as urbanization continues and industry expands.

The Chongqing Gas group distribution utility more conservatively projects that by 2015 its gas supply will rise by 70 percent compared to 2010 levels based on:

- Doubling of the gas delivery capacity of Chongqing's traditional gas supplier, CNPC Southwest Oil and Gas field Company, through development of the new Luozjiazhai and Longgang gas fields in Chongqing.
- Completion of a new pipeline from Zhongwei in Ningxia that would allow Central Asian gas to be routed from the Second East West trunk pipeline to Chongqing.
- Completion of the pipeline from Burma through Yunnan and Guizhou Provinces to Chongqing.
- Supply of 2 billion cubic meters or more of gas from Sinopec's new Puguang field in Sichuan just outside Chongqing, which made initial deliveries in 2010.

Over the longer term, Chongqing is considered a promising source of shale gas. But neither the central government nor consumers anticipate that non-conventional gas will be a significant contributor to supply by 2015 (Chongqing Gas Company Prospectus, 2012).

5.3.1 Pricing and CMM Potential

State-fixed wellhead prices for gas from the Sichuan gas fields to Chongqing were as follows in mid-2012 (**Table 66**).

TABLE 66: SICHUAN GAS FIELD WELLHEAD PRICES, AUGUST 2012 (CNY/M3)

End Use Category		
Chemical Fertilizer	0.92	0.966
Direct sale to industry (other than fertilizer) by pipeline company	1.505	1.58
Sale to industry by gas distribution company	1.55	1.6275
Other sales by gas distribution company	1.15	1.2075

Source: NDRC (2010.2)

Because of its proximity to the Sichuan gas source, Chongqing only pays about 0.12-0.13 CNY per m^3 for pipeline transmission to the citygate. Average citygate prices for the Chongqing Gas distribution utility were slightly more than 1.3 CNY per cubic meter in 2011.

Due to low citygate prices, as well as the municipality's long history of gas use, the Chongqing Municipal government has fixed retail sales prices of the distribution companies at levels among the lowest in China (**Table 67**).

TABLE 67: REGULATED NATURAL GAS RETAIL PRICES FOR GAS DISTRIBUTION UTILITIES, CHONGQING MUNICIPALITY, AUGUST 2012

End-use Category	
Industrial user:	2.24
Residential:	1.72
Commercial:	2.29
Sales to CNG manufacturer:	1.746
Municipal lighting and other infrastructure	2.29

Source: Chongqing Price Bureau (2010.1), Chongqing Evening News (2010)

From a supply-demand point of view, there is no doubt that purified CMM is welcome in Chongqing. Furthermore, the Municipality's coal mining companies, led by the Songzao Coal and Electricity Company under Chongqing Energy Investment Group, have recovered significant volumes of methane for many years for mine area civil use. The Chongqing Gas Group for a number of years has purchased about 50 million tonnes per year of pipeline quality CMM from the Chongqing Energy Investment Group's Zhongliangshan Coal mine located near the municipal center. As of mid-2012, Songzao was constructing a 100 million cubic meter (100 percent methane basis) CMM purification and liquefaction plant.

Chongqing's low prevailing gas wholesale and retail prices pose economic challenges for purification facilities such as Songzao's. The Zhongliangshan methane purchases do not really provide a precedent, as the Chongqing Gas Company has only paid about 0.5 CNY per cubic meter for what is essentially treated as a coal mining byproduct; the transaction, furthermore, is less than arm's length given the common ownership of both the mine and the gas distribution utility.

It is not clear in the construction phase how these marketing/pricing issues will be resolved for the Songzao facility. Possibilities include:

- Applying a low or even zero transfer price from mine to purification plant for the extracted CMM, which is administratively feasible given the common ownership of Songzao and Chongqing gas.
- The gas distribution company absorbing all or a portion of potential losses until Chongqing conventional gas wholesale prices rise to a level that makes purified and liquefied CMM cost competitive. The Chongqing Gas Group could accept such an arrangement in view of gas shortages and the relatively modest volumes involved the shortage of natural gas in Chongqing.
- Transporting the LNG to areas such as Guangdong in which prevailing wholesale and retail prices are significantly higher until gas prices rise in Chongqing.

5.4 Henan Province

5.4.1 Regional Natural Gas Demand

5.4.1.1 Consumption and Demand

Despite the striking increase in the volume of Henan's natural gas consumption to 7.4 billion cubic meters in 2012, natural gas accounted for no more than 3-4 percent of primary energy supply in Henan (**Table 68**). As is the case throughout China, supply is constraining consumption, and will likely continue to do so for the rest of the decade, barring breakthroughs in supply of shale gas, evident as of 2014. A ten-year development plan by the Henan Provincial Reform and Development Commission projected that, were adequate supply available, demand in Henan would be at least 16 billion cubic meters in 2015, more than twice the level of consumption in 2012, and to approximately 29 billion cubic meters in 2020.

TABLE 68: HENAN NATURAL GAS PRODUCTION AND CONSUMPTION, 2008-2012 (MILLION CUBIC METERS)

	2008	2009	2010	2011	2012
Production	1,122	2,958	672	500	500
Consumption	3,823	4,150	4,721	5,496	7,392

Source: CESY 2013, , pp. 43, 96

As shown in **Table 69** and **Figure 34**, industrial and residential consumption of gas both rose substantially between 2009 and 2012. These trends will continue for the foreseeable future, given the enormous unmet potential for fuel switching in industry and the desire of urban residents for clean fuel. Even with the growth of recent years, it is doubtful that more than about 55 percent of Henan's urban residents are connected to natural gas.

The slow growth of natural gas consumption in power plants will likely also continue through the decade, or at least as long as gas is priced higher than coal; on a heating value basis; natural gas is about 3.5-4.5 times higher than coal in Henan (pricing section below), and the NDRC discourages rapid inflation of electricity prices. Unlike the coastal regions, inland provinces such as Henan do not appear to be at the tipping point where the combination of environmental pressures and wealth begin to influence decisions to build new coal fired power plants.

The NDRC is, however, encouraging the construction of a series of natural gas "distributed energy centers" which provide a combination of central heating, air conditioning and power to large industrial and commercial enterprises, and is formulating regulations that will require the power grid company to purchase the excess power that they generate. The electronics assembly giant Foxconn completed Henan's first such center together with the power generator Huadian in 2013, which includes two 33 MW gas turbines (China Thermal Power Web, 2011).

TABLE 69: HENAN COMPOSITION OF NATURAL GAS CONSUMPTION,2009-20012 (MILLION CUBIC METERS)

Industry	2,893	2,532	4,940
Electric Power	769	1,376	1,001
Residential	389	609	1,010
Other	104	NA	NA
Total	4,155	4,715	7,361

Source: CESY 2013, p. 227;CESY 2012, p. 223; CESY 2010, p. 185

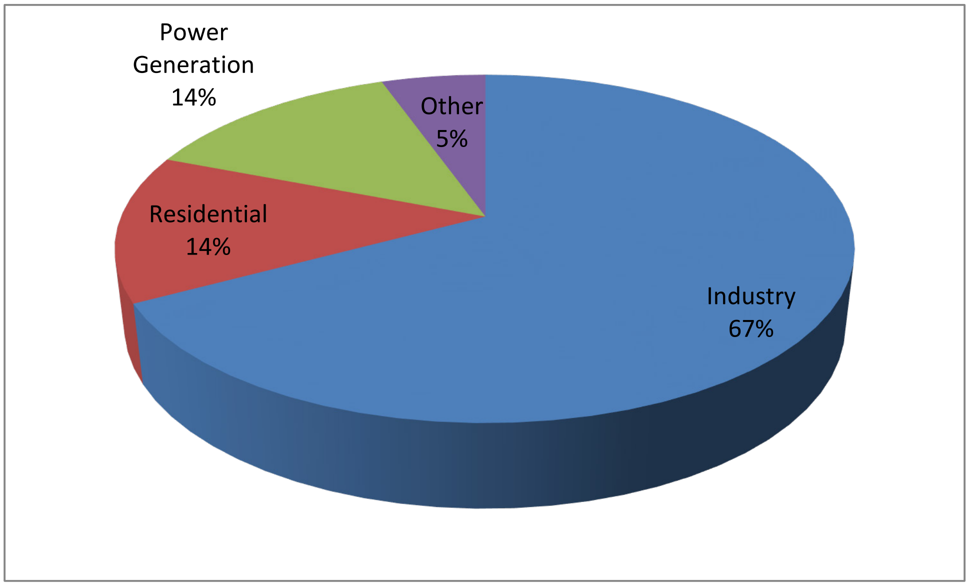

FIGURE 34: HENAN COMPOSITION OF NATURAL GAS CONSUMPTION BY SECTOR, 2012
Source: CESY 2013, p. 227

5.4.1.2 Present and Future Supply

Henan's indigenous natural gas producers consist of the following:

- The declining Zhongyuan gas field located in Puyang in the northern part of the province near Hebi, which launched gas usage in Henan in the 1980s, but now produces only 500 million cubic meters per year (HSB, 2014).
- A 220 million cubic meter per year coal to natural gas plant operated by the Yima Coal Group (Henan Provincial Government Web, 2013)
- CMM producers which emit 1-2 billion cubic meters per year of methane in varying concentrations, of which perhaps 10 percent was recovered and burned in small power CMM power plants or in the local communities in 2013.

Thus, close to the entirety of provincial supply comes from the following sources outside the province:

- Approximately 3 billion cubic meters per year from the Xinjiang gas fields through CNPC's first West-to-East pipeline from Xinjiang to Shanghai (approximately 20 percent of the pipeline's throughput).
- Approximately 3 billion cubic meters of Turkmenistan gas through the CNPC's second West-to-East pipeline from Xinjiang to Guangzhou. By 2015, volumes consumed in Henan could reach 5 billion cubic meters per year under agreement between the CNPC and Henan.
- About 1billion cubic meters from Sinopec's Shaanxi/Ordos basin transmitted via branch pipeline from Sinopec's 3 billion cubic meter Yulin-Shandong pipeline.
- Approximately 500 million from neighboring Shanxi province's Qinbei CBM fields transmitted by pipeline to Bo'ai. Volumes could increase to one billion cubic meters by 2015 (Henan DRC 2011, press reports).

Combined, these sources will provide a maximum of 10 billion cubic meters to Henan 2015 and beyond, well short of what the province could consume. It appears furthermore that only limited volumes of gas from new sources will reach Henan for some years afterwards. According to a 10-year natural gas development plan issued by the Henan Development and Reform Commission in 2011, less than 1 billion of the 30 billion cubic meters from the CNPC's third West-to-East pipeline from central Asia and Xinjiang scheduled to be completed in 2015-2016 were reported to be allocated to Henan. Even if the province succeeds in negotiating a higher allocation, the volumes are unlikely to be comparable to those from the first and second West-to-East pipelines (Henan DRC, 2011; Dahe Daily, 2013).

A series of coal-to-natural gas projects being constructed in the East Junggar area of Xinjiang are planned for completion around 2017-2018 will provide Henan 30 billion cubic meters of new pipeline gasHenan . The Henan Energy and Chemical Group (Hebi Mining Group's parent) is building one of these plants, with 2 billion cubic meters due onstream 2017, and an additional two billion several years later. Henan can expect to be allocated 10-15 percent of the pipeline's throughput. Based on preliminary discussions with CNPC it might get access to an additional 3 billion cubic meters from a fourth West-to-East pipeline to import yet more Central Asian gas that might be completed towards the end of the decade (Henan, DRC 2011; JCoal, 2014).

In short, barring an unlikely discovery of a major new conventional gas deposit or a quick breakthrough in China's shale gas development efforts, which makes major volumes of domestic gas available to Henan, natural gas supply will fall short of demand in Henan for the foreseeable future. From a supply and demand perspective, the province should be able to absorb all pipeline quality CMM that becomes available.

5.4.1.3 Provincial pipeline infrastructure

The introduction of gas from Xinjiang, Central Asia and Shaanxi/Inner Mongolia through long distance trunk pipelines has spurred development of a rudimentary pipeline distribution network connecting the consumption centers in Henan. The largest of these are listed below in **Table 70**.

TABLE 70: MAJOR PROVINCIAL PIPELINES IN HENAN

	Capacity (billion m^3/year)	Owner	Main Gas Source
North to South			
Zhengzhou-Zhumadian **Zhumadian-Xinyang**	1.0 0.4	Henan Lantian Group	CNPC 1st West-to-East pipeline
Bo'ai-Anyang	0.7	Henan Ancai Group	CNPC 1st West-to-East pipeline
Luoyang-Bo'ai-Anyang	1.5	Henan Zongheng Gas Group	Sinopec Shaanxi-Shandong pipeline
Huaiyang-Wuhan (Hubei Province)	1.0	CNPC	A connector pipeline between Sichuan-Wuhan and 1st West-to-East trunk line
West-to-East			
Pingdingshan-Xuchang -Zhengzhou-Tai'an	10 (estimated 3 billion consumed in Henan)	CNPC	CNPC 2nd West-to-East pipeline. This pipeline

	Capacity (billion m³/year)	Owner	Main Gas Source
(Shandong)			can interconnect with the 1st West-to-East trunkline in Zhengzhou
Pingdingshan-Luohe	2.0	Henan Huiji Energy Company	CNPC 2nd West-to-East pipeline. Can connect to Zhengzhou-Zhumadian line
Pingdingshan-Zhumadian	2.0	Henan Lantian Group	CNPC 2nd West-to-East pipeline

Sources: Henan DRC 2011

Numerous smaller lines branch off from these lines or from the CNPC/Sinopec trunklines to various consumption centers. The western and southwestern cities in the province are served primarily by the second West-to-East pipeline, the central-southern part of the province by the Zhengzhou-Zhumadian line, and the north-central and eastern parts of the province by the Pingdingshan-Zhengzhou-Tai'an, line, and the various lines from CNPC's first West-to-East line.

The Bo'ai-Anyang and the Luoyang-Bo'ai-Anyang lines pass through Hebi in the far north. Total allocation to Hebi from these two lines is in the 100-200 million cubic meters range. A purified CMM producer would have the option of injecting product into the pipelines as well as into the Hebi municipal network.

5.4.1.4 Natural Gas Pricing in Henan

Starting from July 2013, the NDRC implemented a major change in the natural gas wholesale pricing system which significantly increased the delivered price of conventional pipeline gas to Henan. Under this reform, delivered prices are no longer calculated based on varying wellhead costs from the different oilfields (or import costs for LNG and pipeline gas) plus pipeline transmission fee. Rather, the NDRC publishes citygate wholesale prices applicable in each province, regardless of well field of origin for gas emerging from transfer stations on the trunk pipelines owned by the natural gas majors CNPC and Sinopec (NDRC, 2013.4).

The NDRC established differential pricing by defining old gas, as consumption volumes less than or equal to those of 2012, and new gas defined as incremental consumption in excess of 2012 levels. With the exception of residential consumption and consumption by chemical fertilizer factories, the system of differential pricing according to end-use was abolished.

Under the regulations, the NDRC fixed the price of new gas in Henan and other provinces at 85 percent of the 2012 price bracket for substitutable fuels, consisting of 60 percent fuel oil and 40 percent LPG. Trial citygate pricing regulations promoted in Guangdong and Guangxi provinces prior to the 2013 national scale implementation, the NDRC suggested that it might change the new gas prices annually according to changing prices of the fuel oil/LPG basket. The new gas prices are technically called guidance prices, meaning the maximum allowable, with the pipeline companies free to sell at lower prices. In practice, given short supply of natural gas in China, the guidance prices are likely to be the actual prices for new gas.

Old gas prices were raised substantially, relative to the pre-July 2013 levels, but are still significantly discounted relative to new gas prices (**Table 71**). The NDRC indicated its intent to gradually raise old gas prices to new gas levels by the end of 2015.

Although not mentioned explicitly by the NDRC, enabling CNPC and Sinopec to recoup the higher costs of imported natural gas (both LNG and pipeline) relative to domestic conventional gas was a major consideration behind the change in pricing formula; prior to 2013, the CNPC had been forced to sell imported pipeline gas at domestic gas price levels, accumulating significant losses as a result. The two-tiered old gas/new gas system is designed to cushion the shock of cost increase for existing customers.

TABLE 71: HENAN NATURAL GAS CITYGATE WHOLESALE PRICES (CNY PER CUBIC METER)

New Gas	3.15	NA
Old Gas		
-Civil Use	2.27	1.47
-Industrial Use	2.27	1.87-1.895
-Chemical Fertilizer	1.72	1.47

Source: NDRC 2013.4

The wholesale prices in **Table 71** are not inclusive of the costs charged by pipelines owned by provincial companies or private companies which transport gas from the CNPC/Sinopec transfer stations to cities such as Hebi. Most likely these additional fees are in the range 0.1-0.2 CNY per cubic meter, which would make old gas and new gas wholesale prices in Hebi 2.37-2.47 and 3.25-3.35 CNY per cubic meter, respectively.

Retail prices fixed by the Henan provincial government reflect the blend of old and new gas wholesale prices. As of year-end 2013, the prices in Hebi and neighboring Anyang are as shown in **Table 72**.

TABLE 72: GAS PRICES IN HEBI AND NEIGHBORING ANYANG (CNY PER CUBIC METER)

Industrial users	3.13	3.49
Commercial users	3.13	3.69
Residential users		
-First 50 cubic meters/month	2.07	2.24
-Over 50 cubic meters/month	2.69	2.91

Source: Dahe Web 2011, Henan Province Information Center 2011

Industrial and commercial user prices were readjusted in the wake of the wholesale price changes of July 2013, but the residential prices fixed in December 2011 were not. The average residential customer uses considerably less than 50 cubic meters per month for cooking and hot water, and the first 50 meter increment is lower than the citygate wholesale price for old gas. Quite possibly the prices for residential users will be adjusted upward some time in 2014-2015.

Unconventional gas such as shale gas and CBM/CMM are explicitly excluded from the wholesale price control system, with suppliers free to sell at market price. In principle, CMM producers might expect to sell at the new gas prices; but, they could face some resistance from gas distribution companies until residential user prices are increased.

5.4.2 CMM Market and End-Use Options

Hebi is a region of high demand for energy in all forms, which provides several possible markets for CMM. Firing boilers is a common use of CMM in China, but uses only a small percentage of extracted CMM. Demand from domestic users varies widely daily and seasonally and CMM is often vented during the summer months when it is not needed for heating. Some CMM drained from Chinese mines has been used for coal drying and this is a potential growth market as more Chinese coal is washed to meet increased coal quality standards.

Pipeline sales are an option in the Hebi area. Delivering gas straight to Hebi's citygate pays CNY 1.9/cubic meter. As noted above, however, Hebi might earn a better return shipping LNG to more distant southern markets where wholesale prices exceed 3 CNY per cubic meter than by selling into the local natural gas market.

Many mines use Chinese-made reciprocating engines, especially designed to be fueled by low-concentration CMM, to produce electricity for the mine's use. The engines are relatively low cost, modular and can operate using varying amounts and concentrations of input gas. Heat exchangers on the generators can heat water for radiators or boilers. Power generation from CMM is generally considered less costly and less complex than sales-to-pipeline projects. National policies encourage sales to the grid of electricity generated using CMM, although policies are not widely enforced and local electric grid operators have ignored them in the past.

Mine shaft heating is a mandatory process in northern China to prevent ice hazards and protect miners during harsh winters. In warmer latitudes, gas-powered air conditioning units can be used to cool mine shafts. January temperatures in the Hebi area average -2°C and heat produced during power generation is an option for additional CMM energy recovery.

CMM of sufficient quality can be compressed to reduce its volume for transportation to available markets. CNG use is a growing market in China and it is popular as a vehicle fuel, especially in taxis and with bus fleets because CNG is up to 40 percent cheaper than gasoline. Most production is currently centered near producing gas basins or major pipelines, although some projects have used CBM as a feedstock. Jincheng City in Shaanxi Province, 100 km from Hebi, is a major source of CBM for a CNG processing plant which distributes CNG to central Henan Province.

LNG is used to fill the gap between China's ever-increasing demand for natural gas and its lagging domestic supply. China began importing LNG in 2006 and import volumes have grown rapidly. Total imports are reported to have more than doubled between 2008-2009, with average imports of 12 million cubic meters per day in 2008 and the latest figures of 37 million cubic meters per day in 2009.

Over 60 percent of the imported LNG is used in new gas fired power stations, while the rest is distributed as town gas for residential and industrial end users. China also has almost a dozen domestic LNG plants in operation or under construction and leads the world in small-scale LNG production. When the plants are all on-stream, they will produce between 6 and 7 million cubic meters per day, equivalent to 15-20 percent of current import volumes. As noted above, the Songzao CMM to LNG project is underway.

5.4.2.1 Consumer Base in the Hebi Area

Henan Province is China's most populous province, with an estimated 2007 population of 98.7 million (HSY, 2008). Hebi is a major industrial area with a large residential population. As such, there is a large demand for both electrical power and natural gas in the area and this demand is predicted to grow steadily at rates of 5-10 percent a year. Hebi City receives natural gas via a trunkline from the West-to-East pipeline and has a well-developed gas distribution system. The city is supplied with electricity from a local coal-fired plant and major transmission lines from the regional grid. Hebi City is a transportation hub with good rail and road access to Beijing and the region's major cities.

Industries

Hebi is now a medium-sized industrial city and a transportation hub for northern Henan Province. With the development of a new industrial and technology area, spurred by the availability of nearby industrial mineral resources, the city's population has increased rapidly to over 1.4 million, while its 2007 GDP growth was 18.2 percent (HESDR, 2007).

Hebi's mix of light and heavy industries include agricultural products processing; coal mining and dressing; raw chemicals and chemical products; electronics and machine manufacturing; metallurgy; electricity and heat production and supply; and rubber products manufacturing. Proven dolomite reserves in the area are approximately 1 billion tonnes and source a local, energy intensive magnesium production industry. China now produces more than 60 percent of the world's magnesium.

The province leads the country in the production of grain and oil-bearing crops and is a big producer of cotton, meat, poultry and eggs, all of which lead to Henan Province being an important food processing base. The thriving agricultural sector means that 66 percent of the population resides in rural areas. The province also has extensive mineral resources, including large reserves of bituminous, anthracite and coking coal, along with deposits of iron ore, bauxite, mica, lead, molybdenum, gold and silver. These natural resources have provided the base for the growth of large scale industrial development led by engineering, nonferrous metallurgical, and textile industries, and Henan Province is a national leader in lead, aluminum, and glass production. Zhengzhou, the provincial capital, lies in the heart of the cotton-growing area and is one of the main focal points of China's textile industry.

Nearby cities

Xinxiang is located 37 miles to the south-west of Hebi and is the chief city of northern Henan. Situated at the junction of major east-west and north-south rail lines, Xinxiang is also linked by the highway network to the three large provincial cities of Zhengzhou, Kaifeng and Luoyang and via expressway to Beijing. In addition to cotton-textile production, spinning, and dyeing, its industries now include food processing and the manufacture of electronics, pharmaceuticals, machinery, automobiles and automotive parts, and chemicals. The city has grown rapidly to an urban population of 5.5 million.

Anyang, with a total population of 5.2 million, lies 25 miles to the north-west of Hebi. It has been a regional agriculture and trade center for centuries and is located on the main north-south rail line from

Beijing to Guangzhou. Established textile mills and food-processing plants have been joined by heavy manufacturing and high-tech industries.

5.5 Guizhou

5.5.1 Regional Natural Gas Demand

As of early 2014, Guizhou is a virtually untapped gas market. The province has no known conventional oil or natural gas deposits. Despite Guizhou's proximity to the gas fields in neighboring Sichuan Province, the central government has chosen to allocate the output of these fields to more populated, developed provinces. As a result, no pipelines link Guizhou to Sichuan with the exception of a short, dedicated pipeline across the Yangtze River to an ammonia/urea fertilizer complex in the city of Chishui on the Sichuan border. This single facility accounts for the vast majority of the reported 500 million cubic meters of natural gas reported to have been consumed in Guizhou in 2007 (CESY, 2008 Table 5-22; Cnlist, 2010).

Token amounts (perhaps 10-20 million cubic meters per year) of LNG from several small Chinese plants have been trucked into Guizhou since 2006 to serve only a small number of residential customers and automotive CNG users in various cities. With the commissioning of the Dazhou small-scale LNG plant in Sichuan in 2010, these shipments may increase on the order of 100 million cubic meters per year.

CMM is a major potential source of non-traditional natural gas for Guizhou. But at present, the vast majority of liberated CMM is lost as VAM. Of the 684 million cubic meters recovered in 2009 province-wide, all but 84 million were reported to be vented to the atmosphere (Xinhuanet Economic News, 2010). No CMM is known to have been used outside of the immediate mining areas.

5.5.2 Future Demand and New Supply

Significant volumes of natural gas will enter Guizhou starting from approximately 2013 when the CNPC pipeline from Burma is scheduled to be completed. Guizhou political leaders have made a preliminary commitment to purchase up to three billion cubic meters of the pipeline's 12 billion annual flow by 2020 (Guizhou Capital City Newspaper, 2008). Initial volumes will undoubtedly be lower; between one and two billion cubic meters is a reasonable estimate.

The trunk pipeline will enter Guizhou from Yunnan Province to the west and run a reported 300 km eastward through Anshun Municipality, Guiyang, Duyun Municipality, Dushan and Libo Counties and onward to Guangxi Province. The Guizhou Gas Group has developed preliminary plans for a network of branch pipelines from the trunkline, including a line that would run north from Guiyang towards the city of Zunyi.

A proposed 15 billion cubic meter per year pipeline from Ningxia Province in the north to the Guizhou capital city of Guiyang would open up Guizhou to significant quantities of gas from the northwest. The central government is unlikely to grant CNPC final permission to proceed with the line until it has secured a gas source, most likely from Turkmenistan through the so-called third West-to-East pipeline, currently in the planning and negotiation phase. Officials in Guizhou have expressed the hope that this pipeline could be completed at approximately the same time as the pipeline from Burma in 2013, but of securing the gas source could delay the project for several years (Sichuan News, 2010; International Gasnet, 2010).

Total demand is difficult to determine in the absence of supply, which itself tends to stimulate latent demand. Based on current estimated usages in Guizhou, natural gas substitution for other fuels would create demand in the vicinity of 1.5 billion cubic meters, as follows:

- About 1 billion cubic meters of natural gas to replace the estimated 2 billion cubic meters per year of coal gas currently burned as fuel in the province.
- 470 million cubic meters of natural gas to replace the estimated 400,000 tonnes per year of fuel oil currently consumed in the province.
- 175 million cubic meters of natural gas to replace the estimated 125,000 tonnes per year of liquefied petroleum gas (LPG) such as propane and butane currently consumed in the province (CESC, 2008 Tables 3-14, 3-15, 5-18; GSB, 2010 Table 5).

Residential consumption, which has been a major driver for natural gas development in many other locations, is likely to play a somewhat more modest role in Guizhou, with its small population and low urbanization level. If all of Guizhou's reported 11.4 million urban residents were to consume natural gas at the approximately 70 cubic meters per year per capita level of residential customers in Chongqing, total residential demand would be about 800 million cubic meters. Consumption at commercial facilities such as stores and restaurants would amount to an additional 100 million cubic meters, judging by the ratio of commercial to residential consumption in other parts of China.

Rapid development of industrial and other non-residential markets will therefore be necessary to absorb the considerable volume of new supply of natural gas likely to enter Guizhou starting from 2013. The significant number of heavy industry factories in Guizhou offer particularly promising potential markets. These, in addition to the industries that the CNPC is reported to be working with, include aircraft and other military equipment facilities, steel mills, cement plants, and phosphorous processing plants.

Guizhou Gas Group will be partially responsible for the development of these markets. The CNPC itself, however, appears to be taking direct responsibility for the marketing of some of its Burmese gas in Guizhou. Reports indicate that the CNPC plans to:

- Set up a network of 12 major CNG production sites and 120 to 150 CNG automotive filling stations throughout the province;
- Construct four combined cycle power generation stations to be used for peaking power;
- Develop residential distribution networks in a number of localities; and
- Create natural gas industrial parks, and sell directly to existing major industrial energy users such as the Guizhou Aluminum Factory and the Maotai Spirits Factory (Huaxia, 2010).

In summary, the size of the market in Guizhou is likely to exceed initial expectations once natural gas is actually present and the convenience and environmental benefits of natural gas are experienced for the first time. The speed at which this transformation occurs, however, is hard to predict, and there remains some possibility that the supply of new pipeline gas may temporarily exceed in-province demand.

5.5.3 CMM Market and End-Use Options

An in-province pipeline network has been planned to distribute Burmese gas. Additionally, the Guizhou Gas Company has contemplated a pipeline network that would extend to Renhuai County, approximately 30 km east of Linhua, but has not indicated how quickly this network will be constructed.

Prior to the anticipated arrival of gas from Burma in 2013, Guizhou should be able to absorb LNG produced by Linhua. Even if supply temporarily outstrips demand for the first few years after the arrival of pipeline gas, local distribution companies under the Guizhou Gas Group-and possibly even those under CNPC-will have an interest to retain a reliable local supplier like Linhua, in order to hedge against the risks of supply interruption from Burma and to supply the parts of the province that are not initially covered by the new pipeline network.

The estimated citygate Guizhou price of 2.8 to 3.0 CNY per meter for Burmese gas will establish the baseline for the ex-LNG plant price that Linhua would be able to charge a distribution company. Given the reported 0.1 CNY per 100 km tanker truck transport cost for LNG produced by other CBM producers in China and the approximately 300 km distance from Linhua to Guiyang, 2.5 CNY per cubic meter represents a reasonable estimate for the price that Linhua could expect to receive.

Locations outside of Guizhou may offer attractive markets for CMM. Shortages of gas in larger, more developed provinces such as Guangdong, or even Guangxi, are likely to remain acute even as supply of imported gas pipeline gas and LNG increases. The unserved or underserved medium-sized cities in these provinces offer particular possibilities.

Wholesale prices to Guangdong/Guangxi for imported LNG or pipeline gas from Central Asia and the Northwest will likely be 3.5-4.0 CNY rather than 3.0 CNY as in Guizhou. This would compensate for the higher transport costs to the markets in Guangdong and Guangxi, located 1,000 to 1,500 km distance from Linhua. Private natural gas distribution companies with franchises in these areas have indicated informally those prices as high as 3.0 CNY per cubic meter could be considered for LNG produced in the Chongqing-Guizhou area.

5.5.4 Pricing

The provincially owned Guizhou Gas Group is the predominant distribution company both for coal gas and for the limited volumes of pipeline natural gas currently distributed in the major cities of Guizhou such as Guiyang, Zunyi County. The prices it can charge its customers for both coal gas and natural gas are fixed by The Guizhou Provincial Price Bureau.

Due to their political sensitivity, prices to residential consumers are lower than costs in many locations. Nonetheless almost all distribution companies throughout the country operate with at least a small profit due to the willingness of the local regulators to allow significantly higher charges to industrial and commercial customers in order to ensure full cost recovery.

The difference between the wholesale prices paid by the distribution companies and the prices that they charge to residential customers typically fall in the 0.5-1.0 CNY per cubic meter range. The comparable mark-ups to industrial users can be as high as one to two CNY. Generally speaking, wholesale price increases are passed on to final consumers, sometimes with a time lag.

In view of the varying costs of the upstream gas source, retail prices vary widely by region. The range for prices to residential users near year-end 2010 is approximately as follows:

- 1.0-2.0 CNY per cubic meter in cities such as Chongqing, located near major gas fields;
- 2.5-3.0 CNY per cubic meter in heartland cities served by long-distance domestic pipelines;
- 3.5-4.0 CNY per cubic meter in cities dependent on LNG imported under long-term contracts; and
- 4.5-6.0 CNY per cubic meter in certain cities in Guangdong and eastern provinces dependent on spot LNG purchases or LNG from the small domestic plants.

Natural gas prices to residential and commercial users in the city of Kaili, Guizhou, at a reported 3.18 CNY per cubic meter and 3.49 CNY per cubic meter, respectively, fall roughly in the middle of this spectrum (Chemnet, 2009). After a round of increases in 2010, Guiyang pipeline coal gas distribution prices reached rough equivalence with the Kaili natural gas distribution prices on a heating value basis (Guizhou Price Bureau 2010.1, 2010.2). These prices will inevitably shape Guizhou price regulatory authority expectations for price of natural gas from new sources.

5.6 Inner Mongolia

5.6.1 Supply and Consumption

The most populated regions of Western Inner Mongolia are located in close proximity to the CNPC's Changqing gas field, which overtook Xinjiang to become China's largest producer as output increased more than three-fold from 2005-2011 to 27.2 billion cubic meters in 2011. Changqing straddles the Shaanxi-Inner Mongolia border region. Although its output is officially considered to originate from Shaanxi Province, in fact a substantial amount is gathered in the Wushen Banner (County) area of Inner Mongolia's Ordos Municipality.

The majority of Changqing's output is shipped eastward to Beijing-Tianjin, as well as to the provinces of Shanxi and Hebei enroute through three pipelines with total capacity of over 30 billion cubic meters. About 4-5 billion cubic meters are shipped south through two pipelines to Xi'an and other cities in Shaanxi province; as production rapidly increases, a third pipeline with initial capacity of 3 billion and additional capacity of 9 billion was in planning as of mid-2012. As much as 1 billion cubic meters are sent southwest through another pipeline to Yinchuan, the capital of Ningxia.

Inner Mongolia itself consumed an estimated 5-6 billion cubic meters of pipeline natural gas from the Changqing field in 2011, with potential to rise to about 9-10 million cubic meters per year through existing pipelines and other facilities including:

- Pipelines of one billion and six billion cubic meters capacity from Changqing to the provincial capital Huhehaote, which also serve the province's other major urban center Baotou, and the center of Ordos Municipality.
- The 245 km, 460 million cubic meters per year Changqing-Western Inner Mongolia pipeline running through Ordos Municipality to an industrial park east of Wuhai Municipality.
- The 900 million cubic meter pipeline running northwest through Wuhai Municipality to Linhe on the north side of the Yellow River.

- A 350 MW power plant at the gas field, which consumes an estimated 250 million cubic meters per year.

TABLE 73: NATURAL GAS SUPPLY AND CONSUMPTION IN WESTERN INNER MONGOLIA

	2006	2007	2008	2009	2010	2011	2012
Changqing Gas field Output	8,047	11,010	14,420	18,952	22,349	27,221	NA
Inner Mongolia Consumption	3,053	2,651	3,053	4,429	4,532	4,084	3,784

Source: CESY (2010); Shaanxi Statistical Bureau (2011, 2012)

Consumption has been somewhat more industry driven than in the rest of China, with residential use accounting for only 12.2 percent of the total in 2009 (**Figure 35**). Use of gas as a chemical feedstock is notably higher than in most other areas.

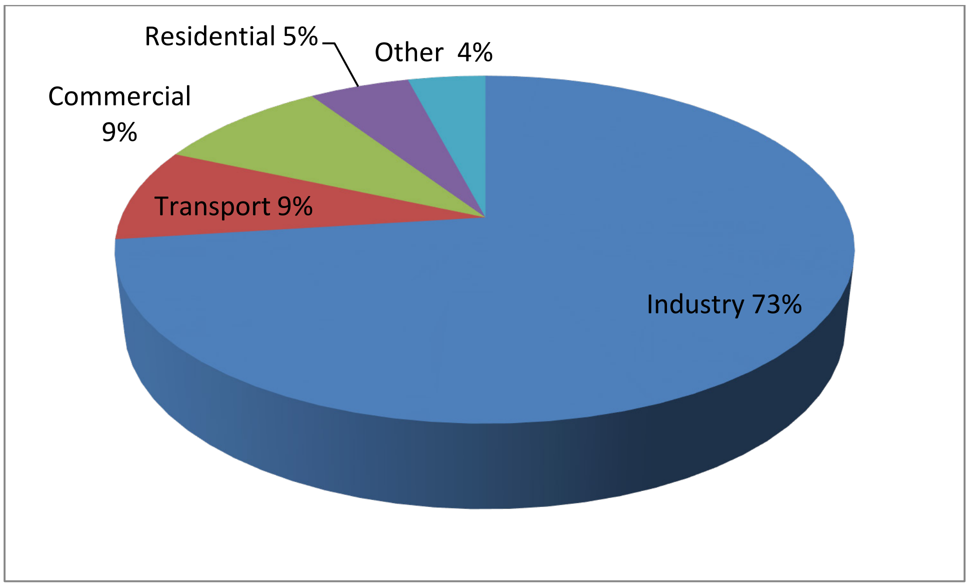

FIGURE 35: INNER MONGOLIA NATURAL GAS CONSUMPTION, 2009

Source: CESY (2013) p.161

Residential and commercial consumption should rise significantly as Huhehaote and Baotou begin to absorb larger volumes of gas through the new pipeline; however, industry may always account for a disproportionately high share of gas consumption given Inner Mongolia's resource based economy.

5.6.2 Pipeline Gas Pricing

Changqing field wellhead prices as of mid-2012 are shown below in **Table 74**.

TABLE 74: WELLHEAD PRICES FOR CHANGQING FIELD GAS, MID-2012 (CNY/M³)

Industrial use	1.355-1.4	1.49-1.54
Chemical fertilizer feedstock	0.89	0.979
Non-industrial	1.0	1.1

Source: NDRC (2010.2)

Pipeline transmission prices to Huhehaote, Baotou, and major developed areas of Ordos Municipality are reported to be in the vicinity of 0.2-0.235 CNY/m^3 (Government of Inner Mongolia, 2010). Prices charged by the Huhehaote Gas Company to its customers were as follows in **Table 75**.

TABLE 75: HUHEHAOTE GAS COMPANY RESIDENTIAL AND NON-RESIDENTIAL GAS PRICES

Residential customers	1.82 CNY/m^3
Non-residential customers	2.0 CNY/m^3

Source: Inner Mongolia Communist Party (2010)

5.6.3 Small LNG Plants

A series of LNG plants with total aggregate capacity close to one billion cubic meters per year have been completed or are under construction in western Inner Mongolia and other locations within a relatively short distance of the Changqing gas field. These plants are listed below in **Table 76**.

TABLE 76: LNG PLANTS IN INNER MONGOLIA AND SURROUNDING AREAS

Location	Owner	Capacity (million m^3 equivalent)	Feedstock	Date completed
Linhe, Inner Mongolia	Huayou Gas Company Ltd. (controlled by CNPC subsidiary)	90	Changqing pipeline gas	2011
Etuokeqian Banner, Ordos City, Inner Mongolia	Shitai Company (local distribution utility)	54	Changqing pipeline gas	2010
Hangjin Banner, Ordos City, Inner Mongolia	Xinsheng Gas Group	45	Changqing Pipeline Gas	2010
Hangjin Banner, Ordos City, Inner Mongolia	Xinsheng Gas Group (LNG manufacturer)	180	Changqing Pipeline Gas	2012
Jingbian County, Shaanxi Province	Xilan Natural Gas Group (gas distribution utility)	150	Changqing Pipeline Gas	2011
Ansai County, Shaanxi Province	Huayou	60	Changqing Pipeline Gas	2012
Yinchuan City, Ningxia Autonomous Region (Province)	Hanasi New Energy (distribution utility)	240	Changqing and West-to-East pipeline gas	2012

Wuhai City, Inner Mongolia	Huayou	150	Coke oven gas[5]	2013

The gas for these plants (excepting the coke oven gas) comes either from allocations to local governments/distribution companies and/or from extra gas that CNPC manages to reserve for its own use.

Local end-uses include automotive fuel (for the CNPC's own plants in particular), and reserves to be used for peaking by gas distribution companies. With prices for CNG fixed at 3.56 CNY per cubic meter equivalent in Inner Mongolia in 2012, according to the formula tying CNG prices to gasoline prices, liquid fuel probably offers an attractive return relative to other local uses.

A significant portion is also shipped on long-distance tanker trucks to load centers in gas-starved coastal provinces that are willing to pay a premium compared to pipeline gas. As noted above, the prices of LNG from these plants are not regulated by the central government, and the local distributors can earn a better return shipping gas to distant provinces than they can by selling pipeline gas to local customers.

5.6.4 Market for CMM

Low wellhead, transmission, and retail sales prices prevailing in the region surrounding the Changqing gas field present economic obstacles to the sale of purified CMM to either CNPC for pipeline injection or for sale in gas form to local distribution companies. Given the relative abundance of available conventional gas, it is unlikely that a pipeline would be extended to absorb small volumes from a producer such as the Tai Xi coal mines in Alashan League on the west side of the Yellow River. The installation of pipeline to send gas to the nearest city of Alashan, located 47 km from the mine, for domestic supply would reduce the consumption of natural gas in the city, but due to the long pipeline distance required from the mine to the city, this scenario is considered cost prohibitive.

LNG presents a much more feasible prospect for CMM producers. LNG plants could offer mines such as Tai Xi the flexibility to pursue a number of different marketing outlets simultaneously, including local civil use (a possibility in a location such as Alashan that did not as of 2012 have a local distribution system) and higher return end-uses such as automotive use and sales to richer provinces with higher prevailing gas prices.

As can be seen from **Table 76** above, a number of LNG plants with pipeline natural gas have already been built in the region. The coke oven gas project in Wuhai offers a particularly encouraging precedent for the economic viability of a CMM LNG plant. Its purification cost, like that of CMM, is higher than for conventional natural gas allocations to local governments that do not have fully developed local residential and industrial demand and/or are searching for a higher return on gas sales.

[5] Coke oven gas will be captured from nine coking plants in the Inner Mongolia Autonomous Region's Wuhai City and processed in two liquefaction plants. The liquefied gas will be used by Ningxia Petrochemical as a feedstock for fertilizer production (Interfax China, 2012).

6. Comparison of Opportunities between Provinces

6.1 Access to Market

6.1.1 Anhui

In Anhui Province, the city of Huainan presents the best opportunity for CMM utilization. Strong demand for Anhui power in the Yangtze Delta provinces, combined with rapid growth in Anhui provincial power demand would create the best possible circumstances for a CMM power plant at Huainan. In Huainan and Hefei there are a number of commercial and industrial plants that could utilize natural gas. Anhui's provincial leadership called in its energy five-year plan for 2011-2015 for wider use of CMM in Anhui, but without specific reference to the power sector. From a supply and demand perspective, Anhui needs any power that CMM plants could provide. Most of the 10 CMM projects either operating or in development in Anhui are power generation and town gas projects (**Table 77**).

TABLE 77: ANHUI PROVINCE CMM PROJECTS

Name				
Huaibei Mining Group Company	Power Generation	Active (underground)	Operating	Huaibei Mining Group Company
Huaibei Mining Group Company	Town Gas	Active (underground)	Operating	Huaibei Mining Group Company
Huainan Mining Group-Pansan Mine	Power Generation	Active (underground)	Operating	Huainan Mining Group
Huainan Mining Group	Town Gas	Active (underground)	Operating	Huainan Mining Group
Huainan Mining Group	VAM as Primary Fuel for Power Generation	Active (underground)	In Development	Huainan Mining Group
Huainan Mining Group	Boiler Fuel	Active (underground)	Operating	Huainan Mining Group
Huainan Mining Group-Pansan Mine	Town Gas	Active (underground)	Operating	Huainan Mining Group
Huainan Mining Group-CHP 1	Combined Heat and Power (CHP)	Active (underground)	Operating	Huainan Mining Group
Huainan Mining Group-CHP 2	Combined Heat and Power (CHP)	Active (underground)	In Development	Huainan Mining Group
Wanbei Coal and Electricity Group	Power Generation	Active (underground)	Operating	Wanbei Coal and Electricity Group

Source: GMI (2014)

6.1.2 Chongqing

Chongqing has one of the oldest and best-developed natural gas distribution infrastructures in China due to its proximity to the Sichuan gas fields. Despite an aggressive investment program by the Chongqing Municipal government and the five national generating companies in the 2005-2011 period, which nearly doubled generating capacity and led to 13 percent per year growth in municipal power generation, Chongqing continued to depend on outside generation sources for 25 percent of its power supply. The Chongqing Municipal government has put forward a plan to double generating capacity within the city to 20,000 MW or more during the Twelfth Five-year Plan period from 2011-2015. Chongqing has a variety of successful CMM projects including VAM destruction, town gas, boiler fuel, power generation, and an LNG project underway (listed below as "Other") (**Table 78**).

TABLE 78: CHONGQING CMM PROJECTS

Name				
Chongqing Nantong Mining LLC	Town Gas	Active (underground)	Operating	Chongqing Nantong Mining LLC
Chongqing Nantong Mining LLC	Boiler Fuel	Active (underground)	Operating	Chongqing Nantong Mining LLC
Datong	VAM Destruction	Active (underground)	In Development	Songzao Coal and Chongqing Electricity Company Ltd.
Songzao Coal and Electricity Company	VAM Destruction	Active (underground)	In Development	Songzao Coal and Chongqing Electricity Company Ltd.
Songzao Coal and Electricity Company	Other	Active (underground)	In Development	Songzao Coal and Electricity Company
Songzao Coal and Electricity Company-Power Gen Phase 1	Power Generation	Active (underground)	Operating	Songzao Coal and Electricity Co.
Songzao Coal and Electricity Company-Power Gen Phase 2	Power Generation	Active (underground)	In Development	Songzao Coal and Electricity Co.
Zhongliangshan Coal Electricity Gas Co	Boiler Fuel	Active (underground)	Operating	Zhongliangshan Coal Electricity Gas Co

Source: GMI (2014)

6.1.3 Henan

Henan's electricity consumption growth rate fell in 2012, and increased only modestly in 2013, lower than the national average for both years. The overwhelming majority of the power generated in Henan is consumed in-province. Weak electricity demand in Henan from 2012-2013 resulted directly from the weaknesses of its heavy industry, and particularly from the weakness of its aluminum sector.

As is the case throughout China, gas supply in Henan is constraining consumption. From a supply and demand perspective, the province should be able to absorb all purified CMM that becomes available. Henan Province has a variety of CMM project types including VAM destruction, combined heat and power, and power generation. Henan has 14 CMM projects operating or in development as shown in **Table 79**.

TABLE 79: HENAN CMM PROJECTS

Name	Project Type	Mine Status	Project Status	Mining Group(s)
Jinling CMM Power Generation Project	Power Generation	Active (underground)	Operating	Dengfeng Jinling CMM Power Generation Co
Jinling CMM Power Generation Project	Boiler Fuel	Active (underground)	Operating	Dengfeng Jinling CMM Power Generation Co
Hebi Coal Industry Group - Power Gen 1	Power Generation	Active (underground)	Operating	Hebi Coal Industry Company
Hebi Coal Industry Group - Power Gen 2	Power Generation	Active (underground)	Operating	Hebi Coal Industry Company
Jiaozuo Coal Industrial Group	Power Generation	Active (underground)	Operating	Jiaozuo Coal Mining Group
Pingdingshan Coal Group	Combined Heat and Power (CHP)	Active (underground)	Operating	Pingdingshan Coal Group
Pingdingshan Coal Group	VAM Destruction	Active (underground)	Operating	Pingdingshan Coal Group
Pingdingshan Coal Group	Combined Heat and Power (CHP)	Active (underground)	In Development	Pingdingshan Coal Group
Yima Coal Industry Group Co	Combined Heat and Power (CHP)	Active (underground)	Operating	Yima Coal Industry Group
Yima Coal Industry Group Co	VAM Destruction	Active (underground)	In Development	Yima Coal Industry Group

Zhengzhou Coal Industry Group Co - CHP 1	Combined Heat and Power (CHP)	Active (underground)	In Development	Zhengzhou Coal Industry Group
Zhengzhou Coal Industry Group Co - CHP 2	Combined Heat and Power (CHP)	Active (underground)	In Development	Zhengzhou Coal Industry Group
Zhengzhou Coal Industry Group Co - VAM 1	VAM Destruction	Active (underground)	Operating	Zhengzhou Coal Industry Group
Zhengzhou Coal Industry Group Co - VAM 2	VAM Destruction	Active (underground)	In Development	Zhengzhou Coal Industry Group

Source: GMI (2014)

6.1.4 Guizhou

The Guizhou power grid is one of five interconnected provincial grids which are controlled by the state-owned China Southern Power Grid Company (CSPGC). Guizhou has become an important electricity supplier to nearby Guangdong and it is expected that Guangdong will continue to depend on significant volumes of electricity purchase from Guizhou and other CPSGC provinces for the foreseeable future.

Currently, natural gas in Guizhou is limited to LNG trucked in and used for a small number of residential and automotive customers. Guizhou's pipeline network is expected to expand with the CNPC pipeline from Burma completing in 2013. The trunk pipeline will enter Guizhou from Yunnan Province to the west and run a reported 300 km eastward through Anshun Municipality, Guiyang, Duyun Municipality, Dushan and Libo Counties and onward to Guangxi Province. The Guizhou Gas Group has developed preliminary plans for a network of branch pipelines from the trunkline, including a line that would run north from Guiyang towards the city of Zunyi. These developments increase the viability of different kinds of CMM projects, as currently no CMM is known to have been used outside of the immediate mining areas. Guizhou has two CMM projects as shown in **Table 80**.

TABLE 80: GUIZHOU CMM PROJECTS

Name	Project Type	Mine Status	Project Status	Mining Group(s)
Shuicheng Mining Group	Power Generation	Active (underground)	Operating	Shuicheng Mining Group
Shuicheng Mining Group	Town Gas	Active (underground)	Operating	Shuicheng Mining Group
Panjiang Coal Bed Methane	Power Generation	Active (underground)	Operating	Guizhou Panjiang CBM Development & Utilisation Co. Ltd
Hong'guo Mine	Power Generation	Active (underground)	Operating	Junfeng Panshui Coal Mine Co.
Qinglong coal mine	Power Generation	Active (underground)	Operating	Guizhou Nenghua Group

Source: GMI (2014)

6.1.5 Inner Mongolia

Inner Mongolia is served by two separate power grids: (1) the western and central grid operated by the IMPGC, and (2) the considerably smaller northeastern regional grid operated by the NEIMPGC. Inner Mongolia is a significant net supplier of electricity to outside provinces, based on its abundant coal resources, sparse population and modest internal demand, and relative proximity to the Beijing-Tianjin load center. Inner Mongolia has the potential to become an even more significant source of power to the rest of China based not only on its coal resources, but also on the wind power potential created by the Siberian winds sweeping across its sprawling grasslands and deserts.

Low wellhead, transmission, and retail sales prices prevailing in the region surrounding the Changqing gas field of Inner Mongolia present economic obstacles to the sale of purified CMM. LNG presents a much more feasible prospect for CMM producers. The LNG plant offers mines the flexibility to pursue a number of different marketing outlets simultaneously, including local civil use and higher return end-uses such as automotive use and sales to richer provinces with higher prevailing gas prices. There is one CMM project operating and two others planned in Inner Mongolia as shown in **Table 81**.

TABLE 81: INNER MONGOLIA CMM PROJECTS

Name	Project Type	Mine Status	Project Status	Mining Group(s)
Ningxia Wulan Coal Mine Methane Power Generation Project	Power Generation	Active (underground)	Operating	Shenhua Ningxia Coal Industry Group Co. Ltd.
Wuda Wuhushan Coal Mine Methane Power Generation Project	Power Generation	Active (underground)	Planned	Shenhua Wuhai Energy Co., Ltd.
Inner Mongolia Adaohai Mine Gas Utilization Project	Power Generation	Active (underground)	Planned	Shenhua Group Baotou Mining Co., Ltd.

Source: UNFCCC (2012), UNEP (2014)

The Ningxia Wulan project comprises 16 internal combustion engines, with a total capacity of 8 MW fueled with CMM/CBM from the Wulan mine, to produce electricity which is supplied to the local power grid. The project has been registered with a 10 year crediting period as a CDM project and began operation in December of 2010. The Wuda Wuhushan project was registered as a CDM project in August of 2011 and will utilize CMM for power generation with a total capacity of 7 MW. The electricity produced will be supplied to Wuda coal mine area, in replacement of electricity from the North China Power Grid.

6.2 Pricing

In Anhui, the recent average wholesale electricity price is 0.4211 CNY/kWh; however, large industrial users, including coal mines, may pay peak summer prices up to 1.0623 CNY/kWh (**Table 82**). These rates make mine site power projects look attractive in Anhui. Regarding natural gas prices, the citygate price paid in Anhui from the West-to-East Pipeline is similar to retail prices paid by automotive CNG users in Chongqing and similar long-distance pipeline customers in Guizhou.

TABLE 82: COMPARISON OF ELECTRICITY AND NATURAL GAS PRICES ACROSS PROVINCES

Province			
Anhui	0.4211 (coal-fired with FGD) 0.338 (small hydro) 0.61 (wind) 0.75 (biomass)	CNPC Xinjiang gas, first West-to-East Pipeline Residential	1.54
		CNPC Xinjiang gas, first West-to-East Pipeline Industrial	1.965
		Sinopec Sichuan gas, Sichuan to East Pipeline (all uses)	2.16
Chongqing	0.449 (local coal-fired with FGD) 0.5534 (natural gas-fired from Henan)	Industrial	2.24
		Residential	1.72
		Commercial	2.29
		Sales to CNG Manufacturer	1.746
		Municipal lighting/other infrastructure	2.29
Hebi Area/Henan	0.4262 (coal-fired with FGD) 0.609 (natural gas-fired power) 0.28-0.342 (hydro) 0.61 (wind) 0.75 (biomass) 0.5742-0.65 (urban waste-to-energy)	Industrial/commercial	3.13
		Residential (first 50 cubic meters per month)	2.07
		Residential (over 50 cubic meters per month)	2.69
Guizhou	0.3738 (coal-fired with FGD) 0.2334-0.326 (hydro) 0.61 (wind) 0.7938-1.0 (solar)	Cities located near major gas fields (retail)	1-2
		Cities served by long-distance domestic pipelines (retail)	2.5-3.0
		Cities dependent on LNG imported under long-term contracts (retail)	3.5-4.0
Inner Mongolia	0.3109-0.375 (coal-fired) 0.51 (wind)	Industrial	1.355-1.54
		Chemical fertilizer/feedstock	0.89-0.979
		Non-industrial	1.0-1.1

Chongqing benefits from low-priced hydropower with wholesale prices between 0.2 and 0.3 CNY per kWh, significantly lower than the 0.5534 CNY per kWh obtained for gas fired power (**Table 82**). Chongqing's regulated natural gas prices are some of the lowest in China because of its proximity to the gas source and because of its long history of gas use.

Henan's coal-fired electricity prices are similar to Chongqing, and gas-fired power is more expensive at 0.609 CNY/kWh. Henan's industrial and commercial gas prices are high at 3.13 CNY/kWh.

Guizhou coal fired power wholesale prices are slightly lower than other provinces. Guizhou's electric power is expected to remain strongly cost-competitive in view of the availability in Guizhou of inexpensive local coal and water resources. Guizhou is a largely untapped gas market, thus gas prices are based mostly on pipeline and LNG prices. Cities served by long-distance pipelines are paying a high 2.5-3.0 CNY/cubic meter.

Inner Mongolia's coal-fired electricity prices are comparable to Anhui at 0.3109-0.375 CNY per kWh. Inner Mongolia is a significant net supplier of electricity to outside provinces based on its abundant coal resources, sparse population and modest internal demand. The wind power rush of 2006-2011 resulted in the construction of 15,000 MW of grid-connected wind power plants mid-2012, 20 percent of the overall provincial electricity capacity and nearly half of the total, national wind capacity. Wind electricity is sold at 0.51 CNY per kWh. CMM-fired electricity is expected to be sold at this price or lower.

7. Conclusion

7.1 Summary of National Issues Impeding the CMM Market

Though China's government has implemented a number of policies and mechanisms to encourage natural gas CMM development with some success, there are a number of barriers to a widespread and flourishing CMM market. China's abundant low-quality drained CMM is not only unsafe to use, but safely transporting and handling these explosive gas mixtures is unreliable. Additionally, inconsistent laws, such as that requiring use of CMM with methane concentration greater than 30 percent, affects additionality of a number of high quality CMM recovery and utilization CDM projects.

Coal provides 70 percent of the energy consumed annually in China, with only four percent provided by natural gas. Being considerably cheaper to produce than natural gas, coal will remain the dominant power source into the future. Currently, with China's underdeveloped natural gas market, many do not have access to natural gas, limiting the potential market for CMM. Of the estimated 664 million people living in Chinese cities, suburbs, and towns, only 145 million had access to natural gas at year-end 2010. Entire provinces, such as Guizhou, Yunnan, Guangxi, and Ningxia offered virtually no gas to their urban residents, and even highly-developed provinces such as Guangdong and Jiangsu only offered gas to 12 and 22 percent of their respective city and town dwellers.

Given the rapid construction of electricity generation capacity in China since 2003, including many projects still outstanding, there is a distinct possibility that power generation capacity will outstrip demand in many parts of the country over the next three to five years. The appetite for new power construction will likely decrease correspondingly, and dispatch of existing plants-particularly coal-fired power plants-will decrease.

7.2 Summary of Provincial Issues Impeding the CMM Market

In Anhui, many mines are located in rural areas lacking a natural gas market. At the Liuzhuang mine, for example, nearby villages utilize either agricultural waste (straw) or waste coal for heating. Waste coal is abundant and quite inexpensive. CMM in areas such as this would need to be sold at an extremely low price to displace this waste coal. Anhui provides significant power to neighboring Yangtze River Delta provinces on the East China Power grid, which are being restricted on the number of new coal-fired power plants allowed. Scarcity and expense of natural gas in Anhui have prevented the development of combined-cycle plants, limiting the market for CMM and other gas sources for electricity generation.

Chongqing has a well-developed gas infrastructure; however, gas prices are among China's lowest. Chongqing Gas may not prove to be a reliable long-term customer absent administrative direction from the municipal government and/or a major increase in the cost of gas to Chongqing from the domestic producers. This means CMM recovered in Chongqing will most likely need to be sold outside of the province, such as to neighboring provinces like Guangxi and Guizhou.

Chongqing is one of six provincial level units making up the Central China grid. The Central China grid is a net power exporter to the rest of China, with generation exceeding supply within the grid by about 60,000 GWh in 2007. The surplus comes from the rich hydropower resources in the region (hydropower accounted for about one third of the Central China grid's output in 2006, far and away the highest such percentage in the country). The abundance of hydropower in the region makes CMM-generated power less attractive.

In Henan, the trends of slow growth in power plant consumption of natural gas are expected to continue as gas is priced so much higher than coal; on a heating value basis, natural gas is about 3.5-4.5 times higher than coal. Unlike the coastal regions, inland provinces such as Henan do not appear yet to be at the tipping point where the combination of environmental pressures and wealth begin to influence decisions to build new coal fired power plants.

Guizhou is a virtually untapped gas market with limited infrastructure. Token amounts of LNG from several small Chinese plants have been trucked into Guizhou since 2006 to serve only a small number of residential customers and automotive CNG users in various cities, although developments of LNG plants in Sichuan may increase this service. CMM is a major potential source of non-traditional natural gas for Guizhou. But at present, the vast majority of liberated CMM is lost as VAM. Increased drainage will be required in order for CMM to provide significant natural gas to Guizhou. Sales outside of Guizhou are an option as shortages of gas in larger, more developed provinces such as Guangdong, or even Guangxi are likely to remain acute even as supply of imported gas pipeline gas and LNG increases.

Guizhou's disproportionate economic dependence on energy-intensive extraction and manufacture of commodities such as coal, chemical fertilizers and their inputs/associated products, and aluminum, creates the potential for some volatility in electricity demand. Guizhou's focus with respect to distributed power is on solar. Unlike CMM power plants, which were promised subsidies above the coal power wholesale price by the government in 2007-2008[6], but which have not been connected to the grid in a consistent manner, there is a dedicated funding source for the subsidy payments to the

[6] NDRC April 2007 *Opinions Regarding Use of Coalbed Methane and Coalmine* Methane: public grid companies purchase all power generated in excess of mining companies' own needs by CMM generation plants, pay the purchase price in a "timely manner," and pay the CMM power generators the same prices as for power from biomass generation plants, equivalent to the regulated wholesale purchase prices for power from new coal-fired plants, plus a 0.25 RMB per kWh surcharge.

distributed solar plants from the renewable energy surcharge, which was raised in 2013 to 0.015 CNY for each kWh of commercial electricity sold in China (China Southern Grid, 2014).

Low wellhead, transmission, and retail sales prices prevailing in Inner Mongolia surrounding the Changqing gas field present economic obstacles to the sale of purified CMM for pipeline injection. Given the relative abundance of available conventional gas, it is unlikely that a pipeline would be extended to absorb small volumes from a producer such as the Tai Xi coal mines in Alashan League on the west side of the Yellow River. The installation of pipeline to send gas to the nearest city of Alashan, located 47 km from the mine, for domestic supply would reduce the consumption of natural gas in the city but due to the long pipeline distance required from the mine to the city, this scenario is considered cost prohibitive. LNG presents a much more feasible prospect for CMM producers. A number of LNG plants with pipeline natural gas have already been built in the region with good results. The coke oven by-product LNG gas project in Wuhai offers a particularly encouraging precedent for the economic viability of a CMM to LNG plant.

Potential coal mine methane power generators in Inner Mongolia will deal with power grid companies more experienced than in any other part of China in dealing with variable supply from small power suppliers; however, they will have to compete with wind power plants for dispatch in a province that has a much stronger stake in wind power than in CMM. To the extent that they are dispatched, it can be assumed that the CMM power plants will not be able to sell their output at more than the 0.51 CNY per kWh mandated for wind.

7.3 Benefits to Implementing CMM Projects in China

There are multiple benefits to developing CMM projects in China. CMM projects reduce greenhouse gas emissions, improve mine safety, create jobs, improve local and regional air quality, and provide energy independence – of particular importance as China's energy needs are expected to double from 2005 to 2030 (IEA, 2009.1). China has the world's highest CMM emissions, with nearly 13 percent of the world's total in 2010 (USEPA, 2012). With a booming coal market and government policies to encourage natural gas and CMM development, CMM projects are expected to continue to be favored. China is home to nearly all CMM projects registered as CDM projects – an important source of project funding.

7.3.1 Success Stories

As of September 2014, 92 CMM projects have been prepared for the CDM and approved by the central government; of those, 58 projects have been registered with the UNFCCC and CERs issued for 30 of these projects (Huang, 2014). Remarkably, the largest CMM power project in the world is at the Sihe Mine in Jincheng, Shanxi Province. This project uses Caterpillar engines to generate electricity at a 120-MW capacity power plant, utilizing 187 million cubic meters of both CBM and CMM from the Sihe mine (USEPA, 2006.1; Huang, 2008; Sun, 2014). The Sihe project avoids the release of three $MtCO_2e$ annually.

Additionally, China is host to the first VAM project approved by the UNFCCC as a CDM project. The VAM abatement and energy recovery project was commissioned in October of 2008 in Zhengzhou and provides hot water for local use. In conjunction with the VAM project, the Zhengzhou group, comprising nine coal mines, also utilizes extracted CMM to produce electricity for their own consumption as part of the same registered CDM project. The total emission reductions during the third monitoring period (April 2010-March 2012) were 19,321 tCO_2e (UNFCCC, 2012).

The Huainan and Huaibei mining groups have had success with numerous projects in Anhui Province, with seven of the province's eight operating CMM projects. These projects, including power generation, town gas, boiler fuel, and combined heat and power, have all been developed as CDM projects. Annual greenhouse gas reductions estimated from all eight projects totals 3,007,913 tCO_2e, as reported in the GMI database, (GMI, 2014)). Anhui has five registered CDM projects:

- Huaibei Haizi and Luling Coal Mine Methane Utilization Project;
- Pansan Coal Mine Methane Utilization and Destruction Project;
- Huainan Panyi and Xieqiao Coal Mine Methane Utilization Project;
- Anhui Huaibei TaoyuanCoal Mine Methane Utilization Project; and
- Anhui Huaibei Qinan Coal Mine Methane Utilization Project (UNEP, 2014).

The following lists some of the more notable registered CMM and VAM projects located in other provinces discussed in this document. Chongqing has four operating CMM projects (GMI, 2014); all are registered CDM projects:

- Zhongliangshan Coal Mine Methane Project;
- Nantong Coal Mine Methane Project;
- Tianfu Coal Mine Methane Project;
- Chongqing Pingxiang CMM Utilization Project;
- Hechuan Yanjing Coal Mine Methane Utilization Project (UNEP, 2014); and
- Chongqing Datong Coal Mine VAM Destruction and Utilization Project.

The Datong VAM project is expected to reduce greenhouse gas emissions by up to 200,000 tonnes of CO_2e per year (CMOP, 2010). Chongqing will also be home to a CMM purification and liquefaction project underway as of 2014 (see Box).

Henan has nine operating CMM projects and is home to six registered CDM projects:

- Zhengzhou Coal Industry (Group) Co., Ltd. Coal Mine Methane Utilization Project;
- Yima Coal Industry (Group) Co., Ltd. CMM Utilization Project;
- Pingdingshan Coal (Group) Co., Ltd. Methane Utilization Project, Henan Province;
- Jiaozuo Coal Mine Methane (CMM) Power Generation Project of Jiaozuo Coal Industrial Group Co. Ltd., Jiaozuo City, Henan Province;
- Jinling Coal Mine Methane (CMM) Power Generation Project of Dengfeng City, Henan Province, and; and
- Yongcheng Xuehu Coal Mine Ventilation Air Methane Recovery and Utilization Project (UNEP, 2014).

Guizhou has two operating CMM ; six projects are registered as CDM projects in Guizhou:

- Guizhou Jinqiao Coal Mine CMM Utilization Project;
- Wantian Coal Mine CMM and VAM Utilization Project;

- Guizhou Hongguo Coal Mine Methane Power Generation Project;
- Guizhou Panjiang Coal Mine Methane Power Generation Project;
- Guizhou Panjiang Low Concentration Coal Mine Methane Power Generation Project Phase 2; and
- Guizhou Panjiang Low Concentration Coal Mine Methane Power Generation Project Phase 3 (UNEP, 2014).

Inner Mongolia has three registered CDM projects:

- Ningxia Wulan Coal Mine Methane Power Generation Project;
- Wuda Wuhushan Coal Mine Methane Power Generation Project; and
- Inner Mongolia Adaohai Mine Gas Utilization Project (UNEP, 2014).

USEPA CMM Feasibility Study to Result in CMM Purification and Liquefaction Project

Chongqing Energy Investment Group (CQEIG), a state-owned enterprise located in the southwest China municipality of Chongqing, has signed a cooperative agreement with Sichuan DKT Energy Technology Co., Ltd. to build a CMM liquefaction project. The project was initiated based on a USEPA-funded comprehensive feasibility study and first presented as a project concept to the international community at the 2009 M2M Partnership Expo in Beijing. –Feasibility Study of CMM Utilization for Songzao Coal and Electricity Company Coal Mines

The project concept laid out in the feasibility study was to connect six active mines owned by the Songzao Coal and Electricity Company, a majority owned subsidiary of CQEIG, to a gathering system feeding an LNG plant that would liquefy 130 million cubic meters of pure methane annually. Additional methane would have been used to fuel 27 MW of high efficiency gas fired engines. The project announced in 2014 by CQEIG will gather, purify, and liquefy up to 35 million cubic meters of pure methane annually from medium-purity CMM from a single coal mine, the Shihao mine. The resultant 25 thousand tonnes of LNG will be transported by truck to the local market in the Chongqing municipality and in booming natural gas consumption centers to the south and east. Total investment is expected to be 250 million CNY ($40.4 million USD) and the project will commence operations by the end of 2015.

Source: GZICCEP (2014)

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