

The Market for Natural Gas in China

Summary of a Research Program

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Introduction

Natural gas is assuming an important role in China's energy strategy as the country actively seeks new and cleaner sources of energy. Currently, about 70% of China's commercial energy comes from coal, which is a primary cause of the horrendous urban air quality that has made Chinese cities among the most polluted in the world. Coal will be difficult to unseat as it is locally abundant and inexpensive. Over the next few decades, cleaner fuels like natural gas will be essential to powering the growing Chinese economy. However, a large scale introduction of gas will introduce challenges in both supplying gas and stimulating domestic demand. This study will investigate those issues, with a focus on the prospects for gas demand.

Total primary energy consumption in China more than tripled from 426.9 million tonnes oil equivalent (Mtoe) in 1980 to 1,386.2 Mtoe in 2004 (BP 2005). This rapid growth is expected about to continue through 2020 to reach between 1,750 and 2,310 Mtoe (DRC 2003). In the 10th Five-Year Plan (2001-2005) for the energy sector, the central government for the first time began explicitly stressing "energy structure optimization," hoping to diversify from coal to include cleaner energy sources like natural gas. To meet this goal, it adopted a new national energy strategy, which seeks to increase the share of natural gas in primary energy consumption from the current 3% to 9% by 2020. This implies a more than 10% annual growth rate for gas as compared to 5% total energy growth targeted for the same period. In volumetric terms, consumption would rise from 39 billion cubic meters (bcm) in 2004 to 200 bcm by 2020 (BP 2005, DRC 2003), and

would make China the world's fourth largest gas market after the U.S., the twenty-five members of the E.U., and Russia.

Traditionally, the Chinese central planning apparatus has orchestrated major shifts in the energy industry. After setting a growth target, the central government would allocate resources and mandate demand in order to meet the target. The government now faces the challenge of how to incentivize such transitions through market-compatible policies rather than relying solely on central planning. Studies of reforms in other energy industries indicate that such a switch will be neither straightforward nor easy (Zhang and Heller, in press, 2005).

The central government's efforts to expand the share for gas are found in supply networks and demand. In 2002, central government-owned companies began construction of the 4,000 km West-East gas pipeline to connect gas resources in Xinjiang to demand centers in Shanghai. The pipeline began limited operations in 2004 and is expected to have an annual throughput of 12 bcm. China has also contracted for LNG supplies, and the first LNG terminal (in Guangdong) is expected to open in 2006. Central plans envision a more elaborate network of pipelines and LNG terminals, but it is unclear whether future infrastructure development projects will follow a central plan, rely exclusively upon private investment, or (most likely) involve some combination of these two options.

Energy security constitutes an important supply challenge. The central government has placed security of supply, along with affordability, as its most vital energy priorities. The current strategy presently calls for domestic resources to supply 65% of gas demand, limiting gas imports to less than 35% (DRC, 2003). Such restrictions may not be compatible with the vision of a dramatic shift to gas, as they would require accelerated development of China's scarce domestic natural gas resources. Furthermore, the state-owned oil and gas enterprises are challenged by a lack of technical, safety, and health standards, as well as R&D capability and several other indispensable elements of gas development (IEA 2002). Thus, any vision for a large role for gas in China may require new thinking about energy security.

While gas supply options have been the subject of intense analysis, the options and obstacles for gas demand have received less scrutiny. Most research and policy attention focused demand has concentrated on the apparent cost disadvantage of natural gas. Although in recent years, the delivered price of coal has risen especially sharply due to bottlenecks and inefficient markets for rail and barge services, many of these price concerns remain. The central government, while aspiring to promote natural gas, insists that the gas must be affordable because of the developing nature of the Chinese economy. In the absence of supportive policies to keep gas cost competitive, it may be difficult for gas demand to reach levels called for in the central government's projections.

This cluster of important policy issues – the central government role in infrastructure development, energy security, and the relative cost of gas – comprise important research questions. There is a body of previous research related to these questions (see Appendix

A), but most of this work took place before China began massive efforts to construct new gas infrastructure. Our research will focus on demand for gas and, having framed answers to that question, allow for some analysis of the issues surrounding supply networks and security.

Our Research Goals

The purpose of this research is to understand the future competitiveness of natural gas in China and to assess the future growth in gas demand in key Chinese markets under different scenarios and conditions. In doing so, it will supplement and improve the existing research in a number of important ways. First, it will extend the regional gas market analysis by studying Beijing, Shanghai and the Pearl River Delta (Guangdong) in order to analyze key regional differences.¹ These regions represent China's major future gas markets – accounting for perhaps half or more of the nation's total gas consumption by 2020 – but have very different natural gas supply and demand profiles. For example, Beijing will be supplied by piped natural gas, and most demand is likely to come from space heating. As the capital city and host of the 2008 Olympics, Beijing also has a stricter environmental standard and is in the midst of active policy interventions to introduce gas to the local economy. Shanghai will have competing natural gas supplies: piped gas from the west and from the East China Sea, as well as imported LNG. Shanghai is a dynamic economic center and natural gas may find multiple uses in industries, power generation, and to some extent, space heating. For Guangdong, gas supply will be in the form of imported LNG, and the most important user will be power generation and, to a lesser degree, industry. There will be no demand for space heating in Guangdong because of its relatively warmer climate. To organize our research systematically three research teams – one per market – are working with a common bottom-up energy modeling system (MARKAL).

This regional approach will help determine the importance of provincial and local governments on gas sector development. Because these regional governments are likely to place a different premium on factors like urban air quality, cost of gas, or security of supply, it is important to consider how they will behave if given more distributed power. This study will extend the existing body of research by exploring the microeconomic and policy factors that will jointly shape the size and operation of the local natural gas market within each regional market. In particular, we will investigate the complications that arise with local implementation of national policies.

Finally, this study will carefully incorporate potential penetration of new technologies and the introduction of reform policies in the local electric power sector – factors that other studies have largely omitted. We will give particular attention to the potential for improved performance of coal and gas combustion systems and also time-of-day pricing that could reward plants configured for peak power supply.

¹ These three areas have very different economic, energy and environmental profiles and policy priorities. They are all major gas demand centers (Girdis et al., 2000).

Research Protocol in MARKAL

In order to construct a MARKAL model, the user must specify the cost and maximum available supply of primary energy resources, the costs and performance of alternative conversion technologies through which the primary energy sources can be processed into final energy carriers, the costs and performance characteristics of alternative technologies that can be used to convert final energy carriers into energy services, and the level of energy services that must be supplied by the energy system. MARKAL is designed to use these variables to minimize the total discounted energy-system cost over the simulated time period.

Basic Assumptions in the Models:

Population Growth: In all scenarios, the projected population growth rate per region should be based on official data from China's State Economic Information Center and should be consistent across all scenarios.

Economic Growth: In all scenarios, the projected economic growth should be based on plausible estimates. We propose using official growth forecasts from China's State Economic Information Center. Nationwide these growth forecasts envision GDP growth of 8-9% for the short-run and 6-7% in long-run and population growth rates 0.5%-1% in 2005-2020. All currency units in the model will be RMB to avoid issues surrounding purchasing power parity conversion.

Fuel Pricing for Gas, Coal, and Oil: The base runs require business as usual international price projections for natural gas, coal, and oil. Each team will develop an algorithm that determines domestic fuel prices based upon the international prices of these fuels. In the meantime, the Stanford team will prepare a memorandum for the teams on fuel price projections based upon credible data sources and our own assumptions. In the policy scenarios we may vary these prices to

Exogenous Power Supplies: Prices of delivered hydropower, solar, and wind will be treated as exogenous in the models.

Interest Rates: Interest rates should remain constant across regions and model runs. However, interest rates could vary depending on the type of capital investment to reflect the differing cost of capital between state-financed and private projects. The Beijing team will explore the sensitivity of the models to changes in the assumed discount rate, and will run the model with a discount rate of 4% and 8%.

Technologies: Technology availability should be constant across all three regions, although the particular technologies that are selected for use will presumably vary. Some technologies are likely to improve on price, others on performance, while still others are mature and unlikely to improve much in the coming decades. Like the fuel price study, the Stanford team will prepare information as to how groups should model technological improvement.

- Limits on urban air pollution
- Changes in fuel prices and availability
- Increased development and penetration of advanced technologies
- Reform of electricity pricing
- Changes in capital markets and availability of capital

Within each of these areas, we would like to explore a number of specific policies as outlined in the following section. Based on characteristics of each region's gas market each group will focus on specific area that are:

- **Beijing:** electricity generation, heating
- **Shanghai:** electricity generation, heating
- **Guangdong:** electricity generation

Business as Usual (BAU):

The BAU scenario will be designed to simulate the demand for total energy and natural gas for the three markets through 2020 in the absence of major policy changes. This run will incorporate information provided in the "Basic Assumptions in the Model" section, with the following constraints:

- The availability of natural gas will be constrained by supplies that are currently available and in existing central plans. For out years, we assume an extension, at current growth rates, in the provision of gas infrastructure.
- The availability of coal will be unlimited.
- The supply of electricity can be met only by internal sources and import (if any) will be limited by current value.
- The availability of renewable energy (mainly wind turbines), hydroelectric, and nuclear power will be provided to the level that is consistent with projects and targets that are currently in the central government plans.

Policy Scenarios:

The policy scenarios will examine some or all of the five main policy goals that could be pursued by the central or regional governments. Within each of these policy goals, there are a number of different specific policies that could be modeled. The actual scenarios selected for the study will depend on the feasibility of simulating the policy using MARKAL and the likelihood of the policy being enacted. Possible scenarios are described below.

- 1) Improve urban air quality.

Possible Model Runs:

- Restrictions on emissions at the smokestack (in effect, forcing different technologies into the model)

- Limits on the operation of coal-fired electricity generators in the vicinity of urban centers
- Tightening of ambient air quality standards.

2) Increase fuel prices to market levels and increase domestic availability.

Possible Model Runs:

- Coal prices move to international parity. (This model run makes sense only if we decide that the base run will not utilize international prices.)
- Import of LNG causes natural gas prices to move to international levels. (This model run makes sense only if we assume that internal prices are below international levels.) This scenario will be run at a range of different international prices to determine the sensitivity of domestic demand to international prices.
- A strengthening of the RMB causes a decline in hard currency gas costs, which allows a reduction in the internal price of gas. (This model run makes sense only if we find that gas is very price sensitive.)
- LNG provides no limit to the amount of gas China can import – growth in gas consumption is limited only by demand at the international price. (This model run makes sense only if we discover that utilization of gas in the base run is limited by available quantities.)

3) Increase the performance of advanced technologies, such as through an active R&D program.

Possible Model Runs:

- Make advanced technologies available.
- Improve the price, combustion, or emissions characteristics of existing and advanced technologies.

4) Reform electricity pricing.

Possible Model Runs:

- Require utilities to purchase electricity produced by distributed generators at retail-like prices.
- Institute time-of-use electricity pricing

The Guangdong team will attempt to simulate time-of-use electricity consumption, which could be used to explore the impacts of time-of-use electricity pricing in a future policy scenario.

5) Changes in capital markets and capital availability.

Possible Model Runs:

- Raise interest rates on all investments to international levels

- Allow differing capital costs depending on the debtor – large, centrally financed projects would pay no interest while smaller, privately funded projects would pay international interest rates.

Expected Model Outputs

It is expected that the model will be able to provide outputs over five-year increments through the expected ending date of 2020. For each of the following results, the model will provide data for 2005, 2010, 2015, and 2020.

Energy Balance:

- Primary energy consumption
- Coal consumption by sector
- Natural gas consumption by sector
- Electricity generation by fuel and technology
- Energy imports by fuel

Emissions:

- NO_x
- SO_x
- CO₂
- Particulate matter

Financials:

- Investments by sector
- Operations and maintenance costs
- Total system costs
- Total investment requirements

Report Outline

- General context of model from each province
- Full input information provided in Excel format with explanations of variables
- Main results for the Business as Usual scenarios
- Interpretation of the results

Appendix A: **Existing Studies of China's Natural Gas Future**

Several studies have investigated China's natural gas futures. BEEC (2003), which supports the recent government energy strategy, looked at three development scenarios. In all three cases, the Chinese economy will quadruple in size between 2000 and 2020 as the central government plans. Three policy situations were simulated to fuel the economic growth: (A) No specific energy policy; (B) Moderate policy to promote energy saving technology and energy diversification, as prescribed in the 10th Five-year plan and currently implemented; (C) Intensive economic, energy, and environmental policies to adjust industrial structure, improve energy efficiency, promote clean fuel, and utilize favorable international energy markets. The result shows that natural gas will be non-competitive and see insignificant development under both Scenarios A and B. The limited demand growth will most likely come from the residential and services sectors. Under Scenario C, natural gas will be further used in power generation, particularly for peak load, power and heat cogeneration and multiple systems that also include cooling. Annual national gas demand will reach 160 bcm under this optimistic situation.

Studies by IEA (2002) and Dong and Logan (2002) have pointed out that the Chinese natural gas development follows the traditional government-managed and supply-pulled model and questioned the sustainability of this strategy. They find a familiar development story. The central government will invest through state-owned gas enterprises and finance through state banks and security markets. Local government and other investors, including foreign, will be invited. "Cost plus" pricing will be used to assure capital recovery and rate of return. There will be weak cost control or efficiency mechanism. If the gas is too expensive, there will be administratively forced off-take or some degree of compensation and price concession. This will lead to complicated economic and political maneuvers at the local level to offload the burden and/or seek economic rent. Foreign investors will be discouraged because of risks and uncertainties. Both studies recommend a more market-based model with political, institutional, and regulatory support for investors. The most important element of this new model and key to the success of the natural gas growth strategy is the emergence of gas allocation and pricing based on consumer willingness to pay. However, projections of this future market demand for natural gas are still poorly understood.

A few studies have also taken a closer look at local natural gas development in the Shanghai area. Chen et al (2001) and Chen (2003) studied natural gas development in Shanghai. They included natural gas in the municipal energy system to investigate its environmental and health impact. Because of their interest in the environmental and health consequences of energy consumption, natural gas availability is only assumed in their MARKAL model either as a constraint or quantitative policy variable. Wei and Zhou (2003) provided a simple *ad hoc* comparison of the competitiveness of natural gas against alternatives on the basis of current government controlled energy prices, cost structure of end-users, and potential fuel switching costs. They conclude that the high costs of natural gas and the associated technological conversions, along with insufficient

policy, law, and regulation are likely to be impediments to the government gas development plan.

Recognizing power generation as the most important aspect of future natural gas demand, Girdis et al. (2000) focused on the competitiveness of natural gas in the electric power sector. Using the Generator of Electric System Planning model (GESp II), the researchers projected demand for natural gas in Shanghai under least cost power development and merit order dispatch.² Non-power sector demand was also calculated on the basis of government estimates to add to the total municipal gas demand. However, the study did not take into account power market competition, which was implemented in China after the study, and acknowledged that “(T)he reform of the power sector, which is designed to expose generators to short-term competition, could make it considerably more difficult for new gas-fired power stations to provide the long-term guarantees required for the gas off-take agreements (p.72).” Moreover, the projection made simplifying assumptions that gas would be available at the price between \$3 - \$5.5/MMbtu because of unavailable cost data of domestic gas supply and complicated financing and institutional issues related to gas supply development. With Henry Hub gas prices more than double these figures, it is important to consider the impacts of much higher gas prices.

² The research was collaborated with ERI in Beijing and East China Power Grid which services the Yangtze River Delta Area including Shanghai.

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