

Recent Development in China's Greenhouse Gas Emissions and Assessment: A Trip Report

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Abstract

In this report we take up the recent energy sector development in China and its consequence for the country's greenhouse gas emissions. In particular, we focus on the energy efficiency improvement and fuel switch, and conduct interviews on the government energy and environmental policies and decision factors behind the energy sector development, both at the national level and in one local (Shenyang of Liaoning Province) economy. These factors include market and price reforms, law and institutional environment, financial and technological constraints. The preliminary data suggests that China does not have a designated GHG emissions control policy and the emission reductions are achieved mainly through the domestic energy and environment policies designed to the meet domestic energy, need and deal with regional environmental problems. Both energy efficiency and fuel switch are likely to receive continued government policy support because they constitute important means to ease the energy constraint to and environmental cost of China's economic growth. However, the energy sector modernization, therefore the reduction in GHG emissions are likely to continue to be hampered by suboptimal decisions due to problems associated with market and institutional reforms, financial and technological constraints, as well as insufficient government policy support.

Glossary

CDM	Clean Development Mechanism
GEF	Global Environment Facility
GHG	greenhouse gas
MFA	Ministry of Foreign Affairs
MST	Ministry of Science & Technology
NMB	National Meteorology Bureau
SEPA	State Environmental Protection Administration
SDPC	State Development and Planning Commission
SPCorp	State Power Corp
SSTC	State Science & Technology Commission
SYEPB	Shenyang Environmental Protection Bureau
SYETC	Shenyang Economic and Trade Commission
UNFCCC	United Nation Framework Convention on Climate Change

Trip itinerary

The trip went from November 2 through November 24. It covered Beijing, Shenyang of Liaoning Province and Wuxi of Jiangsu Province.

November 2,	State Development and Planning Commission
November 3,	State Power Corporation
November 4,	China National Academy of Environmental Science Press
November 5,	Center for Energy, Environment and Climate Change Research Institute, Energy Research Institute, Energy Efficiency Center
November 10,	Beijing University
November 12,	Shenyang Mayor's office
November 13,	Environmental Protection Bureau of Shenyang
November 15,	Environmental Protection Bureau of Shenyang
November 16,	Economic and Trade Commission
November 17,	Northeast Power Corporation (cancelled)
November 18 to 21,	Tenth APEC Inter-Utility Demand Side Management Liaison Group Meeting, Wuxi, Jiangsu Province
November 24,	State Statistical Bureau Press

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Introduction

Our goal in studying the international policy options for mitigating greenhouse gas emissions (GHG) in China is to seek answers to several questions. What are the main contributors to China's GHG emissions that are at the same time the best opportunities for the abatement effort? In particular, what is the role of China's energy system? What are the determinants of this energy system? How are they likely to change and influence the energy system modernization and the country's GHG emissions? Through this process we gain a general understanding of the trajectory of China's GHG emissions that is consistent with its economic growth and energy system development and how international policy instruments such as Clean Development Mechanism (CDM) may be implemented and work.

The study of the determinants of China's future GHG emissions involves some serious difficulties. They arise because of two important characteristics of China's economy. First, China is not a full market economy. In particular, the energy sector is more centrally planned than market-oriented. Compared to the market economy, the Chinese firms, public and private, have different business objectives, operate in a different institutional and organization environment and face different internal and external constraints. This system is known to be responsible for the inefficiency of the Chinese energy sector, which is an important factor behind China's GHG emissions. However, it requires a careful study of the changes in the decision parameters to know how this system would evolve and affect the energy sector optimization.

Second, China is undergoing rapid economic and institutional transitions. This very transitional nature of the Chinese economy and the complexity of the reforming process have created great uncertainty about the pace, direction and scope of national energy reform and the pattern of institutional change. This makes it extremely hard to predict the development of the Chinese energy sector and the rate of change.

The purpose of the first field trip is to begin to gain a better understanding of China's energy development and GHG emission issues at the local (Shenyang of Liaoning Province) and sectoral (power and other large coal consumers) levels. The data collection will concentrate on energy efficiency and fuel switch, especially the government policy and economic and institutional constraints that may be decisive to the energy sector modernization and the GHG emission abatement. Since the study is still at the early stage, the second purpose of the trip was to introduce the project both to Chinese researchers and to officials in the central and one local government, and to get initial feedback from them.

The next section reports some basic data gathered from the trip on recent changes in China's energy development, the main economic, institutional as well as policy forces underlying these changes, and the impact on China's GHG emissions. Given the limited time, the data are quite general, qualitative rather than quantitative, and anecdotal. Section three provides some preliminary assessment of the situation and the difficulties China faces in its effort to improve energy efficiency and adjust fuel structure.

Recent Energy Sector Development and Policy

The trip investigation concentrated primarily on two important baseline GHG emission drivers and their determinants. China's future baseline GHG emissions will depend on the changes of several important factors. The biggest driver will be the economic growth, which has so far made China one of the major GHG contributors. The industrial structural change that will be associated with the economic growth will further act upon this growth effect on GHG emissions. A shift away from the traditional energy intensive industries will lower the emissions while the continued reliance on these industries will increase them. Fuel switch, especially the substitution of low carbon energy sources for coal, will be a critical determinant of the level of GHG emissions. Moreover, energy efficiency in productions and conservation by end-users (in the resident sector) will also affect the level of GHG emissions. Among these factors, China has expressed a strong opposition to any GHG emission reductions that would come at the expense of its economic growth. Meanwhile, it has demonstrated a remarkable record of energy conservation and is expect to continue to do so. Consequently, fuel switch and efficiency improvement will constitute the best opportunities for the international abatement efforts.

The improvement of China's fuel structure and energy efficiency will be a function of a number of economic, technological, legal and institutional variables as well as the government policy. The study asked the questions specifically about the changes in these variables and their impact on different aspects of the inefficiencies of China's energy infrastructure.¹ The answers to these questions summarized below are mainly from the interviews with the SDPC group (SDPC) and State Power Corporation (SPCorp) in Beijing, Shenyang Environmental Protection Bureau (SYEPB) and Economy and Trade Commission (SYEDTC) in Liaoning Province.²

China's Climate Change Policy

Who are the GHG policy makers? What is the policy? How has it impacted China's GHG emissions? What will be the future policy changes?

(SDPC): China's Climate Change administration started in the early 1990s. In February 1990, the State Council established the first Climate Change Coordinating Group. It consisted of four working groups, covering the areas of scientific evaluation, impact analysis, climate change policy, and international policy. In 1992, after UNFCCC's first meeting in Rio de Janeiro, the State Council readjusted the Climate Change administration. Scientific evaluation remained under the supervision of National Meteorology Bureau (NMB). The impact analysis group and policy analysis group was merged into impact evaluation group, which was placed under the State Science & Technology Commission (SSTC). An economic analysis working group was established. It was administered by the State Planning Commission. The international policy remains under the Ministry of Foreign Affairs (MFA). The State Planning Commission was in

¹ Energy inefficiency may arise due to different reasons such as suboptimal scales of productions, backward technology or poor management in the energy and other industries, etc.

² The SDPC group include people from three institutions: Energy Research Institute, Center for Energy, Environment and Climate Change Research, Beijing Energy Efficiency Center.

charge of the coordination among these different branches.³ Unlike other Chinese administrative structures, the central climate change policy body does not have the corresponding bureaus at provincial and regional government levels. Thus, the climate change policy decisions are made exclusively at the central government level.

Under the centrally planned economic structure, the SDPC is not only in charge of designing policies, but also responsible for the allocation of resources to energy and other industrial projects. Because of the 1997 government restructure, the SDPC has lost its power in resource allocation, and assumed a sole role of development strategy and macroeconomic policy guidance.

In making the national climate change policy, China believes that it is the developed countries that are mostly responsible for the current global warming problem. They, therefore, should take more responsibility by reducing its own GHG emissions and helping developing countries financially and technologically on favorable economic terms. As a developing country, China's priority is economic growth. Any international GHG emission abatement effort that compromises this priority is unacceptable.⁴ Accordingly, China's climate change policy is in full compliance with its goal of economic growth. In addition, the policy is also determined by three other factors: the need for energy conservation and efficiency, increasing regional pollution problems and international pressure.⁵

To the extent the economic growth is not adversely affected, the government has done a great deal to mitigate its GHG emissions through energy conservation and efficiency improvement. As a result, China has greatly reduced its energy consumption per unit of output.

China has maintained and will continue to maintain the same policy principle. The recent development in CDM will not affect this principle. The developed countries and developing countries including China look at CDM with different objectives. Developed countries take it as a cheap way to solve their GHG emission problem, while developing countries believes it may work only as a means of the capital and technology transfer. The different objectives will give rise to a long-term fight, especially around the baseline estimate. China believes that any baseline has to be bilateral and based on China's growth perspective. It is not in the country's interest to get into the endless fight. CDM or not, China will continue to make their policy according to its domestic economic and environmental needs and focus on energy conservation and efficiency.

(SPCorp): China is basically against GHG reduction because it restricts economic growth although the government expresses its concerns about global warming in front of foreigners. Consequently, the SPCorp would not cooperate with foreign research in this area, and would not provide data for such research. (Even domestic researchers are not granted the access to the data. GHG emissions studies conducted by such places as Tsinghua University is largely based on estimated data.)

³ In 1997, the State Council underwent the structural reform. The State Development Planning Commission (SDPC) replaced the State Planning Commission. The SSTC was downgraded to Ministry of Science & Technology (MST). And the NEPB, renamed State Environmental Protection Administration (NEPA), has been elevated from sub-ministerial to ministerial level. It has been empowered with more say in environmental protection affairs.

⁴ This statement is consistent with "Principles of the People's Republic China on Global Environmental Issues", adopted during the eighteenth meeting of the Environmental Protection Commission of the State Council, Beijing: Chinese Environmental Science Press, 1992.

⁵ A Chinese official in the former Ministry of Electric Power pointed out in his keynote speech at a conference on wind power in 1997, "China has been on the stand of the accused ever since the UN Rio de Janeiro conference. It reminds us that if we (China) do not pay attention to pollution and do not change the structure of the power sources, there will be no way out."

Energy and Environmental Policy Changes

What are recent developments in energy and environmental policies and their causes? What is their impact on fuel switch and energy efficiency?

(SDPC, SPCorp): The goal of the energy policy in the past a few years is to guarantee the energy need of the ninth Five-year plan (1996-2000). A central focus of the policy continues to be the energy conservation and efficiency. Some recent measures in energy conservation include the development of several conservation centers assisted by Global Environment Facility (GEF). These centers adopt a new market approach to broaden the conservation. Green lighting project represents another campaign. SDPC has been devoting resources to help develop and market new product, and educate the consumers. On efficiency, major policy drives include retrofitting or abolishing old, energy inefficient industrial equipment, central heating in the urban area, etc. The state government has published a list of obsolete and/or energy inefficient, environmentally hazardous technologies and equipment. Presently, the government is shifting its efficiency improvement policy towards the backward electricity transmission system. To eliminate the inefficiency of the power grid due to the long-term inadequate investment, the central has just decided to spend RMB 200 billion in the next a few years to modernize the power transmission. (Zhejiang delegate to the APEC meeting in Wuxi)

These measures will greatly enhance the efficiency in the energy sector. For example, the Green lighting project is expected to conserve electricity by 80 percent (?). The modernization of the power transmission system will also significantly lower the current electricity loss during transmission.

(SPCorp): In general, China's energy sector still suffers from poor technologies, production and management methods. It is inefficient in many ways. However, China is changing very fast. New policy measures are numerous and come out everyday. Careful bottom level studies are necessary to fully evaluate their impact on GHG emissions.

(SDPC, SPCorp): The policy on fuel switch has recently shown some new signs. China has for a long time emphasized the development of other energy sources in addition to coal to meet the energy demand. This effort is now assuming on an urgency. In particular, the government starts to encourage the production and imports of natural gas, coal-bed methane and liquefied natural gas. To reach the goal, China is exploring new management and business systems and favorable policies to boost the natural gas industry. In particular, foreign companies can enjoy import duty exemptions and a low value-added tax rate of only 5 per cent. Similar preferential policies have also been formulated to accelerate the development and utilization of coal-bed methane.⁶ At this stage, the natural gas and coal-bed methane supply is planned largely to replace coal used for heating and cooking by the urban residence sector.

In the electricity sector, the ninth Five-year plan has set the strategy to rely on both hydro and thermal and cautiously develop nuclear power. (16 gigawatts new capacity each year between 1996-2000, a seven percent annual growth rate. Total installed capacity will reach 290 gigawatts with a production of 1400 terawatts hour.) In 1997, the government also outlined a "Riding the Wind" mid-term program till 2010 to promote wind power. More specifically, the goal is to import and digest foreign technology, develop domestic capability of producing large wind turbines and construct wind power farms. The short-run goal is to reach a total of 400

⁶ People's Daily, November, 1998.

megawatt installed capacity by 2000. So far, companies from Denmark, Germany, Spain and the US are participating in the program in different forms. To provide the incentive, the government has designed favorable tariff rates to ensure the profit for the investors and the competitiveness of wind power.

The new policy development, especially the policy on natural gas, will have some important impact on China's fuel structure. China's ninth Five-year plan ratified in 1996 specifies that the natural gas production will reach 2.5 billion cubic meters by 2000. This figure has recently been drastically revised. The output for the same year is now projected at 30 billion cubic meters, and it will rise to 70-80 cubic meters by 2010 and 100-110 cubic meters by 2020. This estimate will boost the share of natural gas in total energy supply from 2 per cent of the current level to 8 per cent in twenty year.⁷ In addition, the production of coal-bed methane is projected to reach 10 billion cubic meters annually by 2010.

(SDPC): China's environment policy in the past a few years has been concerned with the trend of rapid environmental and ecological degradation. China now faces twelve severe regional pollution problems, 8 water, 1 solid waste, and three air (coal combustion dust, other industrial dusts and SO₂). SEPA has launched two programs. The first program aims to control the total volume of 12 pollutants by capping the emission volumes of the year 2000 at the 1995 level. The second program, the Cross-century Green Project, is a medium term project till 2010. The program is designed to deal with key areas with severe pollution problems. As the first stage, a total of 1591 projects have been listed. Among them, 28 (1.75 per cent) are related to the greenhouse gas control.

(SDPC, SPCorp): More recently, automobiles have become a big source of air pollution in many large cities. For example, in Beijing, the number of automobiles has been rising rapidly. There are more than 1,300,000 registered automobiles. In addition, there are also an estimated 60 thousand automobiles from outside Beijing on a daily basis. As a result, the concentration of NO_x in the air has risen more than 18% over the last year. The control of urban traffic has become a part of the government's environment policy. Beijing has recently issued several regulations that specify the timetable to phase out inefficient automobiles and require all non-Beijing registered automobiles coming into the city to take emission tests.⁸ As these environment policy measures are targeted at the regional environmental problems, their effect on the GHG emission control is indirectly achieved and may not be very significant.

Like in the case of the climate change policy, changes in China's energy and environment policies are closely associated with the country's economic growth and the development of environmental problems. As these factors continue to change rapidly, China's energy and environment policy will also change in the future. The uncertain nature of the changes may make baseline estimation an extremely difficult job.

Market Reforms and their Impact on Energy Efficiency and Fuel Switching

What are recent reforms and their impact on energy efficiency and fuel switching? What are the future reform plans?

(SDPC, SPCorp): At present, the major market reform in the energy sector is to separate the government from firm business operations. It consists of two elements. First, the

⁷ China National Petroleum Corp. People's Daily November, 1998.

⁸ People's Daily, December 16, 1998.

governments of all levels stop function as managers of state owned energy enterprises, and let the firms operate to maximize profit. The government will instead concentrate on industry development strategy, policy and regulations. Second, the central government transfers their ownership of state enterprises to the governments of provinces in which these firms are physically located. (Despite this change, the firms are still government owned except it is not the central government any more.) This is an important move from the centrally planned economy to the market economy.

The reform is beginning to have both positive and negative impacts on energy efficiency. On the positive side, an important effect is that smaller inefficient power plants and coalmines are being replaced by larger more efficient operations. This is happening because in the past when large enterprises were owned by the central government, provincial governments would not have the incentive to close smaller companies owned by them because they generated revenues and provided employment for the provincial governments. After the reform, provincial governments now own both large and small enterprises and have every incentive to close the small inefficient companies when the closure is necessary. This is important because, in the coastal area, the small power plants that need to be closed have a combined power production that is three times the entire power output of Thailand.

So far, this effect is still limited because the reform is incomplete. Exactly the same problem now exists between provincial and lower level governments. It makes it very hard to close inefficient companies owned by lower level governments. These companies are often more inefficient than the smaller companies owned by provincial governments.

On the negative side, the reform has also weakened the control of the central and provincial governments over the firms. This makes government energy and environment policies hard to implement. To some extent, it has also created some chaotic situations at the local level, which are harmful to the efficiency improvement. (No specifics were offered on this point.)

(SDPC, SPCorp, provincial delegates to the APEC meeting in Wuxi): In price reforms, the situation is somewhat more complicated. In principle, the central government has already lifted the price control on most energy products. The residential electricity price is about the only price that is still regulated by the government. The control serves to keep household electricity at an affordable level. However, due to institutional and other reasons, there exist multiple prices, and markets are often not cleared by prices. For example, in Zhejiang and Fujian provinces, officials of various related offices often slap construction fees and numerous surcharges on the local electricity tariff and keep them as long as possible because it is extremely lucrative. The income is then used to finance all sorts of expenses running from office and residence constructions to portable phone bills. In addition, as the governments often have the right to make purchase decisions for firms under their control, officials often direct firms to purchase electricity and other energy products from a specific producer at a higher price. The practice has been keeping many inefficient firms in operation. Although the specifics may vary, such situation is widely observed.

(SPCorp): Future energy sector reform involves difficulties and uncertainty. This is because the energy reform is an inseparable part of China's macroeconomic reform and is also influenced by the institutional reform. These are all very difficult reforms. Moreover, China is a country in transition. Factors that affect energy decisions change so rapidly that new reform needs come up frequently. For example, the above mentioned multiple price structure that need to be reformed is in part the result of an earlier energy sector finance reform which allows local governments to raise energy development funds by including construction fees in the electricity

tariff. Recently discussed reforms include the separation of the ownership of power plants and grids and the competition among power producers to provide electricity to the grids.

Financing

What is the current situation in energy sector financing? To what extent is this situation affecting the energy efficiency?

(SPCorp): In general, the whole energy sector development is hampered by lack of capital. This directly affects the adoption of new technology and efficiency improvement. The lack of funds is also putting a constraint on the development of such important projects as natural gas. However, two recent changes in energy finance have a positive impact on energy development and efficiency improvement. First, the government has given up its monopoly in energy investment and is now encouraging different forms of private investment in energy projects. Second, in the past, the government kept the funds for new project and for old equipment retrofitting separate. The loin's share of the funds went to new projects every year. The funding practice greatly contributed to the backwardness of energy technologies and inefficiency. Recently, the government has eliminated the distinction of the use of funds. The retrofitting projects are no longer subject to a very limited pool of funds and can now compete with new projects on economic terms.

Law and Institutional Features

What is the current situation with respect to law and enforcement? What are major problems? What is China's perspective on the legal problems involved in foreign investment in energy sectors?

(SDPC, SPCorp): China has been making a great effort to establish a rule of laws in energy and environment regulations. In general, laws are relatively well enforced. The impression of poor law enforcement is due to two problems. First, China is inexperienced in legal system. Some of the laws are not carefully drafted, and are vague in places and some times are very difficult to operate. Second, in China, there are more executive decrees and "policy documents" than laws. Different from laws, these decrees and documents do not have the legal power as the law. They even may not be fair to some parties. As a result, government decrees and orders are not often followed.

(SPCorp, SDPC): Foreign investment in energy sector is very important for energy development and efficiency improvement. Legal problems that prohibit foreign investment in this area will greatly limit GHG emission reductions in China. Legal problems involving foreign firms are two: breach of contracts on electricity purchases and disagreement regarding the rate of investment returns. The first problem reflects the inexperience of the Chinese government and firms in signing contracts. The disputed contracts were often too rigid and did not allow for any unanticipated changes in the situations. Typically, the Chinese side agreed in the contracts to purchase 5500-6000 hours of electricity, while the international standard level of operation is around 5000 hours. When the power supply increased and the demand growth slowed down, it became hard to honor the contracts, as it would mean many Chinese power plants would have to

be shut down. As a result, the purchase was slashed from the domestic as well as foreign companies.

(SPCorp): The second problem is essentially due to two differences. (1) Both sides have different assessments of the investment risks. The Chinese side generally believes that the risk is not very high, while the foreign side believes it is. Often, the foreign risk evaluation is based on bank risk ratings derived from standard risk models. (2) To the extent different risk evaluations exist and no adequate risk premium is offered, foreign firms would require the Chinese government to provide risk insurance. The Chinese side believes the requirement is unfair because when a private company makes an investment decision, it has to take investment risks by itself. Chinese government does not have the obligation to insure private investment risks. These contract and insurance issues constitute major problems in foreign investment in China's energy sector.

Regional issues (Shenyang)⁹

What is the general situation in energy efficiency and fuel structure? How have they changed in the past and what are the causes of the changes?

(SYEPB, SYETC): The energy structure and the inefficiency of Shenyang basically reflect the national situation. Coal accounts for over 70 per cent of total energy consumed. The technologies in many industries are still staying at the 1950s' and 1960s' levels. This technology infrastructure is extremely energy inefficient and environmentally hazardous. The local characteristic of the energy sector is that heavy industries are the major source of energy inefficiency and pollution. Particularly, the biggest polluter is the non-ferrous metal smelter and processing industry, accounting for 61.5% of the city's total air pollution load. Power and heat generation the next, accounting for 11.03% of the city's total air pollution load.¹⁰

What are the major government efforts in improving energy efficiency and environment quality? How does GHG emission and global warming concern the government?

(SYEPB): Shenyang's environment policy follows the central government policy. The major task is to reduction local water, solid waste, air and noise pollution. The SYEPB is aware of the global warming issue. However, GHG emission control is not the direct policy concern.

(SYETC): The energy policy of the municipal government also follows the central government policy and focuses on energy conservation and efficiency.

What are the major difficulties that firms and the government face in trying to improve energy efficiency and air quality?

(SYEPB): Availability of better technology is a serious constraint. One recent example is that the city plans to replace or retrofit small industrial boilers in an effort to increase energy efficiency. It turns out there is nothing to replace them. No domestic boiler manufactures can

⁹ Due to the time constraint and the government bureaucracy the trip was not able to get very detailed local energy and price data. However, the data sources have been identified.

¹⁰ Because of the unfamiliarity of the global warming issue, GHG is often equated to a form of pollution and air pollution data are given. Another focused trip may be able to provide energy consumption data by sectors.

produce the product with better heat performance than the age-old equipment being used. Similar situation can be found in many areas (construction materials, etc.)

Legal situation has been improving. SYEPB now has more power in eliminating sources of pollution and inefficiency. Law making process is also more democratic than before. One recent example is that the electricity-powered trolley buses in the city have become a major factor slowing down the ever increasing traffic. The government plans to replace these trolley buses with gasoline fueled buses. The plan has been rejected by the city lawmakers on the ground that no environmental impact is considered. The city is now considering buses that run on both gasoline and natural gas.

State owned enterprises pose a challenge. Poor economic performance limits their ability to raise fund to make efficiency investment. At the same time, their government ownership shields them from making many required improvements in their energy efficiency and pollution reductions.

(SYETC): Lack of finance remains a serious problem. In addition, the recent government reform in energy sector finance makes the finance of the efficiency investment at medium and small firms even harder. This is because (1) the firms have now lost government funding and have to raise funds from banks; (2) they do not have a own fund of 20 per cent of total investment required by banks for a loan; (3) banks loans usually demand high rate of returns and short payback period. This makes it extremely difficult for the energy sector to use such a loan.

Assessment

The preliminary analysis of the data suggests three things. First, China does not have an independent or designated GHG emissions control policy and devotes few resources to the cause. Although institutions that are more diplomatic (SDPC) insist that China has a strong climate change policy, their elaboration of the policy measures and more candid views from other institutions (SPCorp, SYEPB) point to the fact that the country's GHG emission reductions are achieved mainly through the domestic energy and environment policies, which are designed to the meet domestic energy, need and deal with regional environmental problems.

Second, energy efficiency and fuel switch are likely to receive continued government policy support because they constitute important means to ease the energy constraint to and environmental cost of China's economic growth. Two recent developments in the economy are further having a positive impact on the improvement of energy efficiency. As the country moves gradually towards a market economy, profit maximizing firms are becoming more sensitive to costs than they were under the state ownership. They are taking on more initiatives to improve their efficiency by cutting energy costs. Meanwhile, after a decade investment in the energy production, the supply gap is narrowing down. The recent slack in income growth and reduction in energy demand has even created a temporary excess supply. This situation is providing the energy industry with some precious time to reorganize and get rid of low technology and small scale operations that are typically inefficient. (Without this ease of the supply condition, the recent closing down of small electric power plants in the coastal areas is impossible even though the market reform has provided the incentive to do so.)

Third, the energy sector modernization still faces insufficient policy support and significant economic and institutional impediments. The process is likely to be long and full of uncertainty. The policy weakness is obvious in the fuel switch effort. Although the recent focus

on natural gas makes the fuel switch promising, its role in the fuel structure tends to be limited unless the government further changes its policy. In a growing economy, there will be two cases of fuel switch: (a) Coal consumption reduces and natural gas fills in; (b) Coal consumption does not decline and may even increase, but the share of coal in energy consumption declines because natural gas supply increases to meet the growing need, and at a faster speed than the coal production growth. To distinguish these two cases, we may call the first case fuel (source) switch or coal substitution and the second case fuel (source) expansion or coal supplementation. Other things equal, fuel switch will cause a reduction in GHG emissions, while fuel expansion will cause GHG emissions to grow slower.

For many years, China's energy policy goal is to expand the various energy productions, including coal, to meet the growing demand. The recent decision on natural gas and coal-bed methane development is, in a large part, still an effort to increase the energy supply though it is also related to the severe urban air pollution. The situation may be better termed coal supplementation than coal substitution.¹¹ Although it provides a cleaner alternative to coal to meet new demand, to what extent the fuel switch will happen depends on a relative price that encourages gas production as well as allows it to compete successfully against coal. In this respect, the government policy is typically vague. As the GHG emissions ultimately depend on the reduction of the coal use, a real fuel switch policy will make a greater contribution to the abatement of GHG emissions. (Even then, like in the energy efficiency case, the actual growth of natural gas production will still be subject to financial, technological and other constraints.)

A second weakness of the policy is its short run nature. In China, the rapid economic growth has often put the government under the very restrictive time constraint when making energy decisions. This situation is particularly problematic because it is highly inconsistent with the long term nature of the energy strategies and projects. The inexperience of the government does not help. The inefficient small scale electric power plants in the coastal area is a perfect example. That these inefficient small plants, instead of large efficient plants, were built in the first place twenty years ago is due to the rapid economic growth and huge unmet energy need.

In other areas, the most serious impediment is likely to be associated with the market reform, particularly the ownership reform of the energy companies. Like in other sectors, optimal energy choice depends on a well functioning market where self-responsible agents make their decisions on the basis of economic incentives. China's reform efforts have so far been to decentralize the economic management, separate the government from economic operations and eliminate the official price controls. However, the reform has not solved the ownership problem. At the same time, the traditional manager appointment and career promotion system is still in place.¹² Consequently, firms and their managers still enjoy the governmental political power, and the government and officials still have vested economic interest in the firms.

The complicated economic and political interests give rise to numerous economic incentives and invisible restrictions that distort firms' decisions, leading to the inefficient resource allocation.¹³ The unwillingness to shut down inefficient electric power plants at lower

¹¹ Even though the natural gas is planned to be used to replace coal in major urban areas, it does not constitute coal substitution if the replaced coal is shipped elsewhere to fill the supply gap there.

¹² In the Chinese institutional framework, the appointment and/or promotion of a manager often depends on the manager's personal relationship with the supervising government official, and is not related to his/her management performance. A manager can be moved to an different firm in an unrelated industry and be promoted even if he/she has just bankrupted the firm under his/her management.

¹³ In these firms it is often very hard to know who actually makes the decisions, whose interest the decision maker is seeking to maximize. More often than not it is personal interest and at the expense of the firm's interest.

level governments and the oppositions of other provinces against the mine-mouth power plant in Shanxi are all typical examples. In addition, this state-ownership and associated vested interest also become a big impediment to the enforcement of laws and other problems.

China's energy system development will continue to face financial and technological constraints. The financial problem involves not only a shortage of capital, but also an unfavorable structure. The country lacks a private bond market and institutional investors. Bank loans are the major source of funds for energy projects, which are typically short term because of the opportunity cost. This makes long-term investment in the energy sector extremely hard. This problem, coupled with the large overhead fund requirement, short-run behavior of government appointed managers, urgent energy need, often leads to choice of inferior technologies or inefficient scales of productions. On the energy technology side, China's domestic technology level and ability to develop and build sophisticated energy equipment of large capacities significantly trail that of the western countries. Without the access to the advanced foreign technology, the inferior characteristics of the Chinese energy technologies are likely to persist for a considerable period of time. Nevertheless, the implication of these financial and technology constraints for international GHG emissions policies are more straightforward and certain as compared to other problems.

Appendix

List of People interviewed

Cui Cheng, Ph.D., Center for Energy, Environment and Climate Change Research, Energy Research Institute, SDPC

Dai Yande, director, Beijing Energy Efficiency Center (SDPC group)

Feng Jian Min, Director, Electric Power Management Section and Resources Conservation & Comprehensive Utilization Section, Economy & Trade Commission, Shenyang People's Government

Gao Guanfu, Chief of Tariff Division, Department of Finance and Asset Operation, State Power Corporation

Han Huifang, Deputy Director-General, Department of Price, SDPC

Hu Jianxin, Associate Professor and Division Director, Center for Environmental Sciences, Peking University

Hu Xiulian, director, Center for Energy, Environment and Climate Change Research, Energy Research Institute, SDPC

Hu Zhaoguang, Director, Power Economics Department, Electric Power Research Institute

Lei Tijun, Deputy Chief, Division of Environmental Protection, Department of Planning and Investment, State Power Corporation

Li Zhixiang, engineer, Power Service Division, Jiangsu Provincial Electric Power Company

Liu Tie Sheng, Director, Environmental Protection Bureau, Shenyang People's Government

Liu Zhiping, senior researcher, Beijing Energy Efficiency Center (SDPC group)

Mao Jin, Director, Beijing Economic Research Institute of Electric Power

Shang Zhi, Director, Market Development and Sales Services, North China Power (Group) Corporation

Sun Xiangjian, Vice Mayor, Shenyang People's Government

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