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GOVERNING WATER IN CHINA: IMPLICATIONS FROM FOUR CASE STUDIES

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The Laboratory is part of School of International Relations and Pacific Studies at University of California, San Diego. ILAR gratefully acknowledges anchor funding from the nonpartisan Electric Power Research Institute, BP, plc, the Norwegian Research Foundation and from UC San Diego’s School of International Relations and Pacific Studies.

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Table of Contents

List of Tables

List of Figures

Executive Summary

This report looks into challenges related to how China manages its water resources with a special focus on the interaction between water and energy. It includes a comprehensive review of information about water resources and scarcity as well as the key policy mechanisms that relate to both water and energy. In addition to a broad overview the report includes four selected case studies: 1) the development of synthetic oil from coal; 2) the setting of urban water prices; 3) China's experiments with private sector participation in its urban water sector, and 4) China's South-to-North Water Diversion Project (SNWTP). These four cases look at four quite distinct mechanisms for water governance, from the design of particular water-intensive energy projects to massive water infrastructures and the crucial issues surrounding pricing and ownership.

This report makes three main arguments. First, water scarcity in China, notably in North China, is pressing. The scarcity is reflected not only in quantity, which is well-monitored, but also water quality where monitoring systems and governance mechanisms are much more immature. This scarcity is not just a reflection of China's geography but also a series of mismatches related to how China's planning system has allocated agricultural and industrial activity. For example, China is facing the challenge of supporting one-third of its population, cultivating two-fifths of its farmland, and producing one-third of its GDP with less than eight percent of the nation's water in the north while, at the same time, developing its water-intensive industries (e.g. the power and coal-chemical industry) in coal-rich but water-stressed regions.

Second, China is undergoing five major governance changes on water resource management: 1) from fragmented water management often called as a "multiple-dragon" system to an increasingly integrated approach which is reflected both in the rising power of river basin management commissions and in the creation of one integrated water authority at provincial levels in charge of all water related issues. This shift to integrated management is something that many studies recommend, and it probably is a good trend for China. But integrated management can also lead to many dangers when the integrated and powerful authorities become politicized or do not pursue policies that reflect the true scarcity. In Shanghai, for example, newly integrated water management authorities may have been captured by special interests and adopt water prices that are much too low to signal the city's true scarcity in water supply; 2) increasing government attention to rising natural resource constraints, particularly those related to each other such as water energy nexus, in the decision-making process; 3) an increasing adoption of market-based instruments such as water pricing and water rights transfer; 4) reducing the role of government and seeking private sector participation, at least in a few urban settings. However, although it is still hard to make firm conclusions about the actual experience with private ownership, the initial experience suggests that many of the problems that have appeared in the rest of the world are also

identified in China (e.g. governance gaps or failures in the selection of private partners, contract provisions, cost information disclosure, and assurance of service quality). For private investors the largest challenge is the one that the fundamental conditions that allow for a sustainable private management of water resources rarely exist because water infrastructures are long-lived and costly and private investors fear changes in the regulatory environment that would undercut the financial viability of their investments; and 5) improving public participation in the water management decision-making and implementation.

Third, the four selected case studies in this report reveal three ongoing governance challenges ahead for China's water resource management: 1) in the context of increasing decentralization in water resource management, the ability of the central government to guide the development of industry policies related to natural resources is waning. Local governments are playing a larger role and often driven by an array of pressures such as local economic growth and jobs linked to infrastructure projects that sometimes conflict with the goal of sustainable resource management; 2) in the context of increasing private sector participation and reducing government roles in the urban water sector, the ability of local governments to protect consumer interests is weak. Local governments, for example, have difficulty in accessing commercially sensitive information when confronted with water tariff increases proposed by private-owned water supply enterprises; and 3) continued improvement of information disclosure, for example, detailed costs of water supply services, which remains a major obstacle to fuller public participation in decisions such as those surrounding water tariffs and the many side-effects of water projects such as the massive resettlement of populations displaced by the SNWTP.

Below are the main arguments of the four selected case studies:

a) Development of synthetic oil from coal in China

This case study makes five main arguments. First, the decision to put huge financial resources into synthetic oil projects is rooted in three concerns: a) growing insecurity due to dependence on imported oil; b) a conscious plan to shift more development west ("the Great Leap West," or Xibu Da Kaifa) to balance astronomic growth in the eastern part of the country but continued poverty in the west; and c) rising pressure on natural resources in addition to oil—notably coal and water—that have led planners to focus on developing resources in places where those are relatively untapped while also adopting more resource-efficient technologies such as advanced coal and addressing resource constraints such as availability of water. These three concerns were expressed most acutely in Beijing although each resonated with local governments (who were concerned about local employment), the coal industry (keen to advance projects that utilized coal), and other key actors.

Second, the key central decisions were orchestrated by the government's planning apparatus—notably the NDRC which oversaw development of the synthetic oil industry by providing guidance, funding, and project approvals. Support for this industry has been highly uneven and volatile as NDRC's priorities have changed over time. Today the synthetic oil industry is regarded as strategic technology and that view is likely to remain unless there are significant technological, political, or other changes.

Third, variation in political support for synthetic oil has depended in part on the status of China's domestic oil industry. Indeed, R&D on synthetic oil began in the 1950s but the government suspended it 1967 when the country's Daqing oilfield came on stream. It resumed R&D support after the world oil price shocks of the 1970s, and the central government has channeled huge support since the middle 1990s. In 1993, China became a net oil importer and oil security concerns rose sharply around this time. Support has notably included the 1998 "Coal Replacing Oil Fund" of $1.3 billion USD (11 billion RMB Yuan) to China's first and world's first direct coal liquefaction plant. However, since 2006 the synthetic oil industry has seen three formal notices of project suspensions linked to pressure on scarce natural resources (notably water), uncertainties about the future of world oil prices and supply, sharp rises in coal prices, and concern in the central government that local governments were over-enthusiastic about development of the industry.

Fourth, local governments have been highly entrepreneurial in making use of incentives that the central government provides. Provinces and localities rich in coal have, not surprisingly, been most interested in advanced coal and synthetic oil projects. Indeed, all the largest projects are in settings that combine central incentives and local entrepreneurialism. The city of Ordos in Inner Mongolia, for example, is the host of China's biggest synthetic oil project. Entrepreneurialism takes many forms. In Ordos, addressing local water constraints required the city build a totally new district closer to rivers and far from the old town where water shortages are chronic. The local government has also taken the lead in pressing the Yellow River Commission to transfer water rights from agriculture to industry.

Fifth, these projects have been shaped by the coal industry—in particular the industry's dominant enterprise, Shenhua Group, which has built the world's largest direct coal to liquid plants in Ordos, Inner Mongolia. The recent consolidation of China's coal industry has helped grow potential players in synthetic oil which are getting bigger in scale and more advanced in technology. The industry has also been the epicenter of most innovation, such as in the development of a zero water discharge technology and also CO_2 sequestration.

b) Urban water pricing governance in China

This case study looks at one of the most visible policy instruments that some Chinese provinces and cities have adopted in an effort to manage water scarcity: raising the price of water. Across China, pricing has evolved from a regime where water was almost free to one, today, where in most urban cities prices are high enough to cover, at least, the operation and maintenance costs of most water supply utilities. In the last two years alone many cities have sharply increased their water tariffs. This case explores three issues.

First, while the NDRC in Beijing continues to provide general guidance on water pricing through its subordinate local NDRCs, but local authorities have large discretion in how water prices are set and reflect scarcity of the resource and social affordability. Municipal water resource bureaus set the price for bulk water supply and depletion of the resource; municipal urban construction agencies set retail water supply prices and wastewater treatment charges; municipal price bureaus manage the process of adjusting water prices. This large discretion for local authorities help explain why water prices, more than most other natural resources, vary so widely around the country.

Second, while many factors interact to shape water tariffs, some of the general patterns are very difficult to explain according to normal principles of economic pricing. Some of the lowest prices are observed in cities with high per-capita income (and thus high ability to pay) and scarce water resources (and thus need to signal scarcity with high prices) while higher prices are observed in the opposite circumstances.

Third, the case study focuses on a comparison of Shanghai (low water tariffs and high water consumption) and Chongqing (high tariffs and low water consumption). These two cities reveal that local government's financial strength and the form of political organization both have a big impact on water pricing. Wealthy Shanghai invests more in its urban water sector and can financially afford to subsidize its state-owned water supply enterprises, all of which lose money (compared with Chongqing where the city government has less money but a larger share of its water companies turn a profit). Compared to Chongqing's fragmented water management, Shanghai has consolidated its multiple water-related agencies into one integrated water authority, changing from the old model of "water governing by multiple dragons" to "water governing by one dragon." The integration made subsidies easier to mobilize and deliver.

c) Private sector participation in China's urban water sector

In most areas of infrastructure China relies on state ownership, but in water it has become increasingly popular to seek private sector participation in the urban water sector. This case study examines three aspects of private ownership in China.

First, reform of the water sector began in the 1990s in the context of broader economic reforms in China aimed at encouraging more private (even foreign) investment. These reforms were motivated by the huge need for investment and concern that the traditional state-centered model would lead to inadequate investment and also economically inefficient operations.

Second, while it is still hard to make firm conclusions about the actual experience with private ownership, the initial experience suggests that many of the problems that have appeared in the rest of the world are also serious problems in China. Those include poor public participation in decision making; large asymmetries in power and information between public institutions and private investors; and governance gaps or failures in the selection of private partners, contract provisions, cost information disclosure, and assurance of service quality. For private investors perhaps the largest challenge is the one that has undercut many privately owned water infrastructure around the world: unpredictable government decision-making about contract terms and tariffs leading private investors to fear expropriation of their investment.

Third, this study looks closely at two experiences with private ownership in two Chinese cities: Shenyang and Lanzhou. The case of Shenyang reflects that large information asymmetries and governance failures in the selection of private partners and contract provisions could lead to adverse effects on the local community. Driven by both infrastructure financing needs and local officials' needs for political promotion, the Shenyang government is keen to attract new investment and foreign sources that are relatively easy to tap. In this case local officials developed a joint-venture to build a utility with foreign capital and expertise, but government chose its foreign partner without thoughtful planning and open bidding and rushed into an unequal contract with guaranteed fixed rate of return. Unable to achieve that rate because it proved politically difficult to raise water tariffs and facing continued losses, the government forced termination of the contract and repurchased the assets at huge cost. This outcome was typical of many water infrastructure privatizations, and in 2002 the central government issued a specific circular which banned fixed rates of return for private utility contracts.

The case of Lanzhou reflects that in the context of the increasing private sector participation and the reducing government role in the urban water sector, it is vital to ensure equitable prices and high-quality service with supplemented governance mechanisms such as transparent information disclosure, improved public participation, and well defined and enforced legal instruments. Private ownership of infrastructures requires a government that is highly capable of obtaining information and managing contracts. In this city, as in many others around the world where foreign investments required hard budget constraints and thus higher tariffs to make the books balance, there was strong public opposition to higher tariffs and complaints about failure to yield expected improvements in water quality after private or foreign-owned companies purchase public assets with a high premium.

d) China's South-to-North Water Diversion Project

The single most prominent (and expensive) water infrastructure project is the country's controversial South-to-North Water Diversion Project (SNWTP). While this project is usually viewed through the lens of the engineering challenges, the case study focuses on the governance challenges--including how to build the institutional capacity to finance and operate the infrastructure and the provisions that have been made to ensure the project improves public welfare—especially of the populations that are being resettled due to the project.

This study makes three arguments. First, although the SNWTP is quite a controversial solution to address water scarcity in North China, in fact the water deficits in the north are so large that neither this project nor any single alternative will provide a satisfactory solution. The decision is not only based on economic or food security concerns, but more likely on political concerns, the social stability of North China. The SNWTP is vast in size and unprecedented; its total cost could be $100 billion covering a period as long as 50 years. Extensions, notably to the west, are still in planning.

Second, as the project has unfolded it has been forced to contend with many new challenges—including water quality degradation along diversion channels, economic and ecological impacts on the source areas, a secondary salinization in the receiving areas, migration of alien species and the proliferation of parasitic diseases, and how to design diversion routes to avoid potential geological disasters (e.g., earthquakes and landslides).

Third, perhaps the largest challenge in this project has been moving beyond an engineering-dominated planning culture and building the institutional capacity needed to manage new challenges such as managing finance and a variety of ecological and human side-effects. Partial funding for the vast project is from local governments of water receiving regions. Its collection, however, is far behind of schedule. Water infrastructure is long considered to be part of the national infrastructure in China, with funding coming from central planners, and provinces were not keen to finance national infrastructure. The central government is facing the challenge of balancing conflicting interests among different provinces which all have their own administrative powers and economic interests (water receiving provinces are giving less, while water exporting provinces are asking more), while local governments is facing the dilemma of keeping water prices low to stimulate industrial growth and to subdue public opposition and meanwhile increasing water tariffs to collect the construction fund and to improve water use efficiency.

Another particular challenge has been relocating the 450,000 people displaced by this project—including the 330,000 over three years linked to the Danjiangkou reservoir. This is a resettlement with the similar intensity as the one for the Three Gorges Dam, and china is using such earlier experiences as a model for action on this project. Those lessons include detailed compensation policies, relying on policy-oriented persuasion rather than simple coercion, improving post-resettlement assistance, and significant improvements in the level of public participation. However, it remains a question mark that China could avoid the problem so-called ‘resettlement return’ or ‘second resettlement’ and ensure no repeat of the embezzlement and corruption scandals that were once notorious in the Three Gorges Dam resettlement.

I. Introduction

China's water resource issues, such as water shortage, over-exploitation of groundwater, and water pollution, have attracted extensive worldwide attention and have been covered by major media outlets such as the New York Times, Economist, Science, CNN, and Routers (Yardley, 2007; Economist, 2009; Li, 2010; CNN, 2010; Harrison, 2010; Wong, 2011).

The Chinese government is well aware of the problem and has started reforming its water resource management since the late 1990s. There are numerous discussions both international and domestic on how China could more effectively govern its water resources and tackle the scarcity problem (Pan et al., 2001; Ongley et al., 2004; Cai, 2008; World Bank, 2009; Huang et al., 2010). Integrated water resource management, for example, is one of the most widely mentioned recommendations, as well as adoption of market-based instruments such as water pricing and water rights.

Many critical questions, however, are yet well addressed. For example, what are the major governance changes up to date in China's water resource management both in good and in bad ways and why did they arise? Who in China make decisions about allocation of water and pricing water? How does regulatory environment affect the allocation and pricing? What are the major drivers of both central and local decisions on water-intensive, energy-intensive, or both-intensive projects?

To address these questions, this study conducts a comprehensive review of information about China's water resources and scarcity as well as the key policy mechanisms that relate to both water and energy. In addition to a broad overview the report has focused in depth on a sample of four case studies: 1) the development of synthetic oil from coal; 2) the setting of urban water prices; 3) China's experiments with private sector participation in its urban water sector, and 4) China's South-to-North Water Diversion Project (SNWTP). We selected these cases because they look at four quite distinct mechanisms for water governance, ranging from the design of particular water-intensive energy projects to massive water infrastructures and the crucial issues surrounding pricing (the choice of policy instruments, i.e., between "command and control" regulation and the use of markets) and ownership (the organization of industry, i.e., state-owned vs. private owned firms).

Coal liquefaction projects are both energy- and water-intensive, but almost all coal-rich regions in China are relatively poor in water resources. This naturally makes synthetic oil from coal an interesting case to look into China's water energy nexus. China has risen and become a worldwide leader today on coal liquefaction technology but the central support for the industry has been highly uneven and volatile as the central's priorities have changed over time. What are major drives that have pushed China to go coal liquefaction? Why did the central government change its policies and cool down the industry since late 2006? The synthetic oil from coal case could greatly help us understand how China has governed its natural resources, particularly water and energy resources.

Raising water pricing, one of the most visible policy instruments recommended by numerous domestic and international scholars, is adopted today in most Chinese provinces and cities in an effort to manage water scarcity. In the last two years alone many cities have sharply increased their water tariffs. How are urban water prices being set in China? Are water tariffs universally raised across all major Chinese cities? The urban water pricing case is chosen in this study to test whether the form of policy organization and governance ideology has a big impact on pricing.

In most areas of infrastructure China relies on state ownership, but in water it has become increasingly popular to seek private sector participation in the urban water sector, which brings about new governance challenges different from previous all state-owned settings. Therefore, the purpose of the case is to examine the actual experience with private ownership in China's urban water sector and its implications on potential governance challenges.

The single most prominent (and expensive) water infrastructure project in China is the country's controversial South-to-North Water Diversion Project (SNWTP), which by any means deserve attentions in water governance studies. The SNWTP project, however, is usually viewed through the lens of the engineering challenges, the case study in this report aims to focus on the governance challenges--including how to build the institutional capacity to finance and operate the infrastructure and the provisions that have been made to ensure the project improves public welfare—especially of the populations that are being resettled due to the project.

The structure of this report is organized as follows. The next chapter takes a comprehensive review of information about China's water resources with a special focus on water energy nexus. Chapter three reviews the general context of China's water resource management including its legal environment, institutional arrangement, level of public participation, and adoption of market based instruments. The following three chapters focus analysis on four chosen case studies listed above. The final chapter concludes the major findings.

II. China's water scarcity

1. Introduction

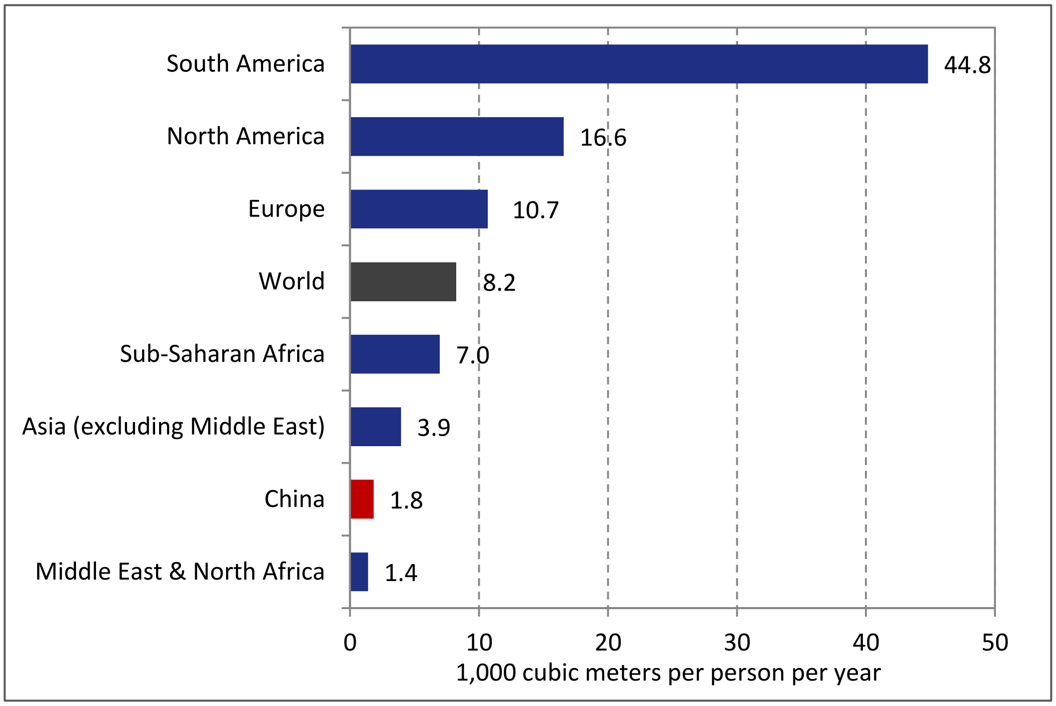
China's water resource issues, such as water shortage, over-exploitation of groundwater, and water pollution, have attracted extensive worldwide attention and have been covered by major media outlets such as the New York Times, Economist, Science, CNN, and Routers (Yardley, 2007; Economist, 2009; Li, 2010; CNN, 2010; Harrison, 2010; Wong, 2011).

The purpose of the chapter is to conduct a comprehensive review of information about China's water resources with a special focus on water energy nexus. This chapter is organized as follows. Section two looks into the quantity problem of China's water resources. Section three turns to another issue, water quality. Section four focuses on the distribution mismatches between China's water, farmland, population, energy resources, and industrial outputs, an increasingly important but not widely recognized problem. The next section re-visits important implication of the mismatch issue by looking into the future growth of water demand by sector. The final section concludes the findings.

2. Quantity: per-capita water resource well below the world average

Averagely speaking, China is not abundant in water resource, although the total amount looks high. Compared to 20 percent of the global population, China has only 7 percent of global renewable freshwater and its per-capita water resources is 1,816 cubic meters in 2009, just one fourth of the world average and 5 percent of the South America average (see Figure 1).

Figure 1: Annual renewable water resource per capita by region



Data source: China data is from NBSC (2010) and other data is from Earth Trend (2007)

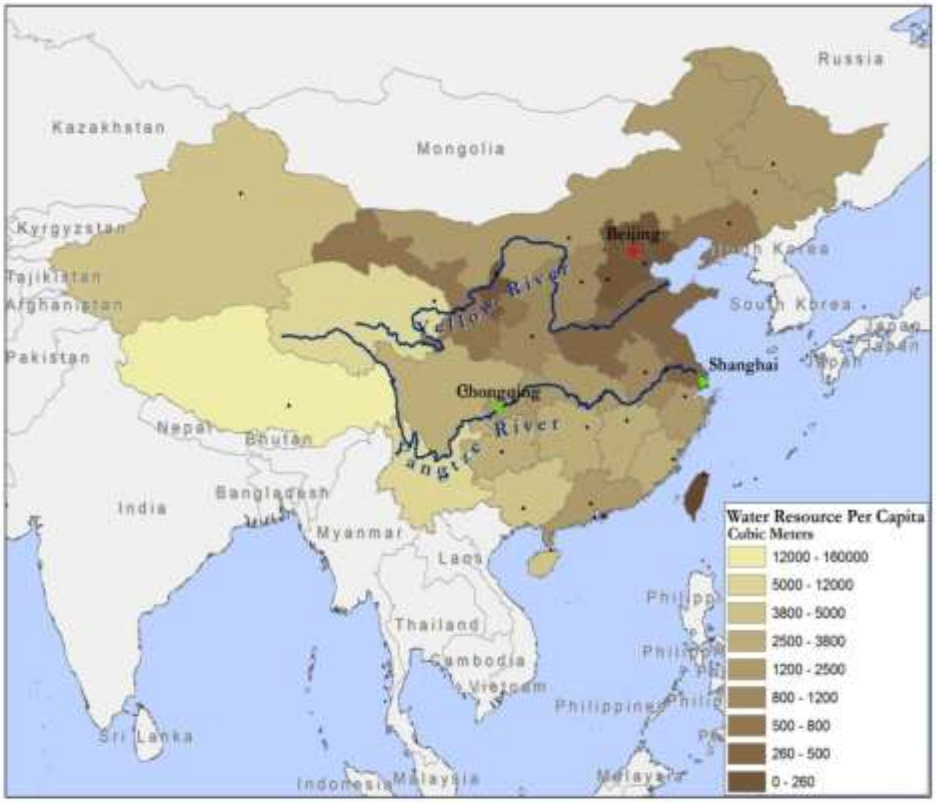
Water is extremely unevenly allocated in China and certain regions in China such as North China are facing severe water scarcity (see Figure 2). Per-capita water resources, for example, are merely 201 and 251 cubic meters in Heibei and Shanxi Provinces, respectively (NBSC, 2010). These numbers are significantly lower than the "absolute scarcity" level of 500 cubic meters per person (see Table 1).

Table 1: Standards to measure water scarcity

	Water availability, cubic meters per capita	Consequences
Shortage	< 1,700	Disruptive water shortage can frequently occur
Scarcity	< 1,000	Severe water shortages can occur threatening food production and economic development
Absolute scarcity	< 500	Absolute water scarcity would result

Source: Adopted from Wang and Jin (2006).

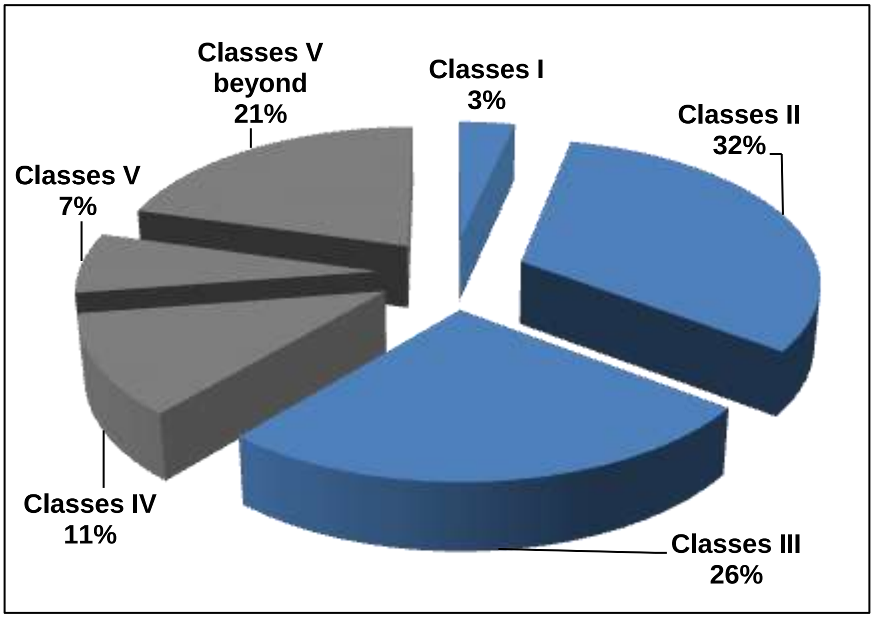
Figure 2: Map of major rivers in China. The increasing brownness indicates decreasing available annual per-capita water resource



3. Quality: water pollution further worsens the problem

Poor water quality further worsens China's water scarcity due to increasing pollution, both of which have caused serious impacts on society and the environment. In China, water quality is broken into five categories that can be described as ‘‘good’’ (Classes I, II, and III) or ‘‘poor’’ (Classes IV, V, and V beyond which cannot support drinking and swimming). About 40 percent of China's river water has "poor" quality (see Figure 3). In water-stressed Northern China, all major river basins experience water quality degradation, and the percentage of monitored water sections ranked good ranges from 32 percent in the Hai River basin to 47 percent in the Yellow River basin (MWR, 2009a).

Figure 3: China's water quality assessment with a total river length of 150,000 km, 2008



Data source: MWR (2009a)

4. Distribution: mismatches between water, farmland, population, energy resources, and industrial outputs

The quantity issue of China's water scarcity is well understood and needs a lot of management efforts, for example, the ongoing controversial high capex South-to-North Water Diversion Project. The quality issue is also widely recognized but yet well managed in China. However, the distribution mismatches and its implications on urban planning and water-intensive energy projects are just recently getting attention. The distribution problem is reflected on two different types of mismatches, one between the distribution of China's water, cultivated lands, population, and industrial output and the other between the distribution of China's water and energy resources including coal, oil, wind, solar, etc.

A notable example is the North China, scare in water but heavy in farmland, people, and industry (see Figure 4). Shanxi Province, for example, has just 0.3 percent of the country's water resources (see Table 2), but needs to support 3.3 percent of its population, 2.6 percent of its cropland and 2.1 percent of its Gross Domestic Product (GDP). Shanghai, Beijing, and Tianjing, three of biggest cities in China, have to sustain a total of 9.3 percent of the country's GDP with just 0.3 percent of the water.

Figure 4: The North China scare in water but heavy in farmland, people, and industry

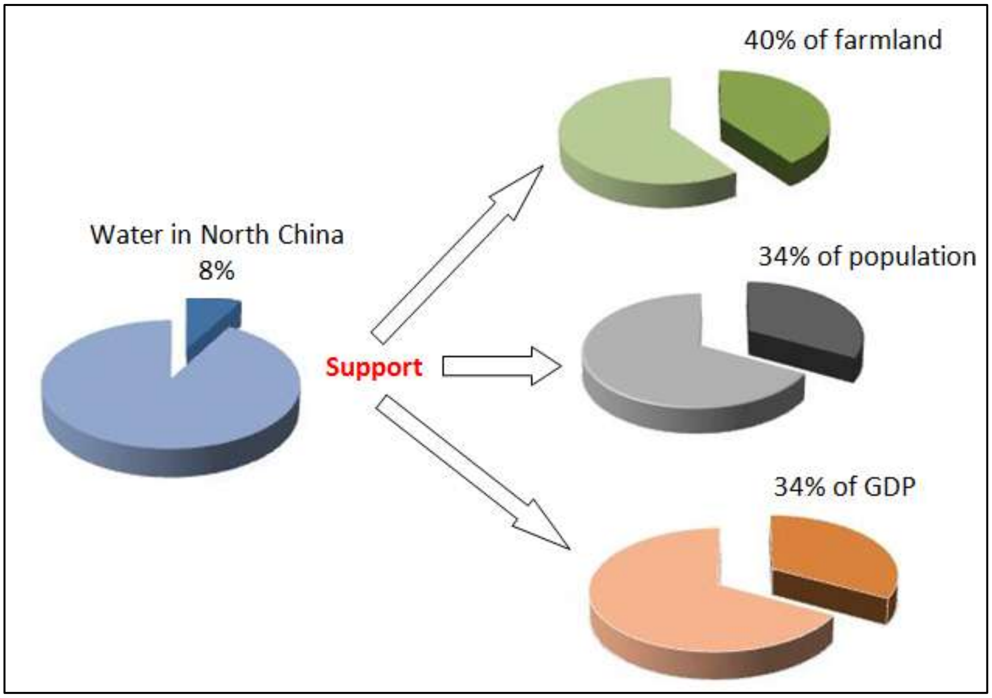


Table 2: Land, population, GRP, and water resources by province in China, 2008

	Cultivated Land		Population		Gross Regional Product		Water Resource		Per-capita Water
	1,000 hectares	%	ten thousand	%	100 million yuan	%	100 million cubic meter	%	cubic meter
Beijing	232	0.2%	1,695	1.3%	10,488	3.2%	34	0.1%	206
Tianjin	441	0.4%	1,176	0.9%	6,354	1.9%	18	0.1%	160
Hebei	6,317	5.2%	6,989	5.3%	16,189	4.9%	161	0.6%	231
Shanxi	4,056	3.3%	3,411	2.6%	6,939	2.1%	87	0.3%	257
Inner Mongolia	7,147	5.9%	2,414	1.8%	7,762	2.4%	412	1.5%	1,710
Liaoning	4,085	3.4%	4,315	3.3%	13,462	4.1%	266	1.0%	618
Jilin	5,535	4.5%	2,734	2.1%	6,424	2.0%	332	1.2%	1,215
Heilongjiang	11,830	9.7%	3,825	2.9%	8,310	2.5%	462	1.7%	1,208
Shanghai	244	0.2%	1,888	1.4%	13,698	4.2%	37	0.1%	198
Jiangsu	4,764	3.9%	7,677	5.9%	30,313	9.3%	378	1.4%	494
Zhejiang	1,921	1.6%	5,120	3.9%	21,487	6.6%	855	3.1%	1,680
Anhui	5,730	4.7%	6,135	4.7%	8,874	2.7%	699	2.5%	1,141
Fujian	1,330	1.1%	3,604	2.8%	10,823	3.3%	1,037	3.8%	2,886
Jiangxi	2,827	2.3%	4,400	3.4%	6,480	2.0%	1,356	4.9%	3,094
Shandong	7,515	6.2%	9,417	7.2%	31,072	9.5%	329	1.2%	350
Henan	7,926	6.5%	9,429	7.2%	18,408	5.6%	371	1.4%	395
Hubei	4,664	3.8%	5,711	4.4%	11,330	3.5%	1,034	3.8%	1,812
Hunan	3,789	3.1%	6,380	4.9%	11,157	3.4%	1,600	5.8%	2,513
Guangdong	2,831	2.3%	9,544	7.3%	35,696	10.9%	2,207	8.0%	2,324
Guangxi	4,218	3.5%	4,816	3.7%	7,172	2.2%	2,283	8.3%	4,763
Hainan	728	0.6%	854	0.7%	1,459	0.4%	419	1.5%	4,933
Chongqing	2,236	1.8%	2,839	2.2%	5,097	1.6%	577	2.1%	2,040
Sichuan	5,947	4.9%	8,138	6.2%	12,506	3.8%	2,490	9.1%	3,062
Guizhou	4,485	3.7%	3,793	2.9%	3,333	1.0%	1,141	4.2%	3,020
Yunnan	6,072	5.0%	4,543	3.5%	5,700	1.7%	2,315	8.4%	5,111
Tibet	362	0.3%	287	0.2%	396	0.1%	4,560	16.6%	159,727
Shanxi	4,050	3.3%	3,762	2.9%	6,851	2.1%	304	1.1%	810
Gansu	4,659	3.8%	2,628	2.0%	3,176	1.0%	188	0.7%	715
Qinghai	543	0.4%	554	0.4%	962	0.3%	658	2.4%	11,901
Ningxia	1,107	0.9%	618	0.5%	1,099	0.3%	9	0.0%	150
Xinjiang	4,125	3.4%	2,131	1.6%	4,203	1.3%	816	3.0%	3,860
Total	**121,716**	**100%**	**130,827**	**100%**	**327,220**	**100%**	**27,435**	**100%**	**2,097**

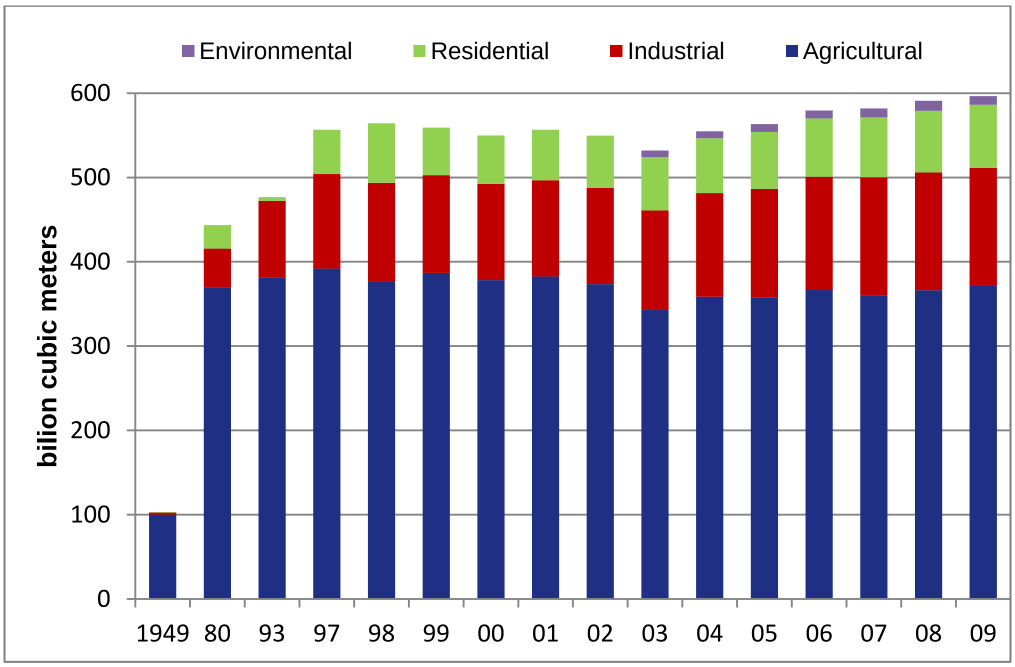
Data source: NBSC (2009)

There is also a mismatch between the distribution of energy resources and water resources. Shanxi Province, for example, have about one third of China's total proven coal reserves, only 0.3 percent of the country's water resources and per capita water resource is 257 cubic meters per person (NBSC, 2009), about a half of the "absolute water scarcity" level.

5. Usage: challenge to meet boosting industrial demand

Statistics show that the biggest increase in future water demand in China is expected from the industrial sector, particularly the energy related industry such as the thermal power industry. Agriculture remains the dominant water user in China, amounting 372 billion cubic meters in 2009, but its share has gradually declined from 97 percent in 1949, 83 percent in 1980, and 73 percent in 1993, to 62 percent in 2009 (see Figure 5). In contrast, the shares of both industrial and residential users have been increasing and accounted for about 23 and 13 percent of the total water use in 2009, respectively. It is projected that in the business-as-usual scenario the agriculture share will decline to 51 percent by 2030, compared to 32 percent for the industry and 16 percent for the residential (2030 Water Resource Group, 2009).

Figure 5: Water withdrawals by sector in China (1949, 1980, 1993, and 1997-2009)



Data source: data from 2000 to 2009 is from NBSC (2010), 1997 to 1999 from MWS (1997, 1998, and 1999) and 1949, 1980, and 1993 from Liu (2006). Data for the environmental sector is only available after 2003 and 1949 and is estimated.

Competition for water among agricultural, industrial and residential users has thus far been tempered by a significant increase in water use productivity in the Chinese economy. Water use per mu (1/15 hectare) of irrigated farmland, for example, declined 9 percent, from 479 cubic meters in 2000 to 435 cubic meters in 2008; while water use per 10,000 Yuan RMB of GDP declined up to 68 percent, from 601 to 193 cubic meters during the same period (MWR, 2001 and 2009a). However, it is projected that an aggregate demand and supply gap by 2030 will be up to 201 billion cubic meters, approximately one quarter of the total demand.

Despite of the increasing adaptation of water-efficient technology, thermal power cooling withdrew about 49 billion cubic meters of water in 2006, by far the single largest source of industrial water demand (see Table 3), and is facing increasing limitations in the rapidly urbanizing basins. Although water withdrawal and water consumption intensities in the industry are both gradually decreasing, the absolute numbers and its shares of the total have been both steadily increasing due to a continuously increasing demand for thermal power production.

Table 3: Water use by the total industry sector and the thermal power industry in China (unit: billion metric meters)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
All industries[1]	113.9	114.2	114.2	117.7	122.9	128.5	134.4	140.3	139.7
Thermal power industry									
Water withdrawals	32.7	37.2	36.4	38.9	43.7	47.3	49.4	-	-
(% of total industry)	29%	33%	32%	33%	36%	37%	37%	-	-
Water consumption	4.7	4.7	4.7	5.4	5.8	6.3	7.1	7.8	7.8
(% of total industry)	4%	4%	4%	5%	5%	5%	5%	6%	6%
Withdrawal intensity (kg/kWh)[2]	29.5	30.9	26.9	24.6	24.2	23.2	20.8	-	-
Consumption intensity (kg/kWh)[2]	4.2	3.9	3.5	3.4	3.2	3.1	3.0	2.9	2.8

Data source: 1. NBSC (2009); 2. CEC (various years)

Note: annual water withdrawals and consumption data are calculated by withdrawal and consumption intensity data and annual thermal power production data from CEC (various years).

If unconstrained by further improved efficiencies, it is projected that industrial water demand will grow at 3 percent annually from 140 billion cubic meters in 2008 to 265 billion cubic meters in 2030, with the highest growth in the next decade. Thermal power cooling will account for 82 billion cubic meters in 2030, about 32 percent of total industrial demand (2030 Water Resource Group, 2009).

Being aware of its water scarcity, China has set itself an ambitious water efficiency target. *National Integrated Water Resources* approved by the State Council in November 2010 set a national target of total water withdrawal no more than 670 billion cubic meters before 2020 and no more than 700 billion cubic meters before 2030 (total water withdrawal was 591 billion cubic meters in 2008 in China). Accordingly, the plan announced ambient decreasing water withdrawal intensities: reducing water withdrawal per 10,000 RMB GDP and per 10,000 RMB industrial outputs in 2020 below 120 cubic meters and 65 cubic meters, respectively, which are about 50 percent lower than those in 2008. These two indicators will be further reduced by approximately 40 percent in 2030 from the level of 2020 to 70 cubic meters and 40 cubic meters, respectively (Yao, 2010).

6. Summary and conclusions

Water scarcity in China, notably in North China, is pressing. The scarcity is first reflected in quantity with national per-capita water resource being only one fourth of the world average and the number being as low as one fiftieth in certain regions. Second, it is reflected in quality, where water pollution is further threatening China's water scarcity while monitoring systems and governance mechanisms are much more immature. Third, China's water scarcity is reflected in two types of distribution mismatches, one between the distribution of China's water, cultivated lands, population, and industrial output and the other between the distribution of China's water and energy resources such as coal and oil. The two mismatches have huge implications on how China's planning system could allocate agricultural and industrial activity while, at the same time, develop its coal-related industries (e.g. the power and coal-chemical industry) in coal-rich but water-stressed regions. Since the biggest growth of water demand in the next decade in China is expected from the industrial sector, notably the thermal power industry, the mismatch between water and energy resources deserves more attentions.

III. Governing water resources in China

1. Introduction

The Chinese government is well aware of the water challenge and has started reforming its water resource management since the late 1990s. There are numerous discussions both international and domestic on how China could more effectively govern its water resources and tackle its scarcity problem (Pan et al., 2001; Ongley et al., 2004; Cai, 2008; World Bank, 2009; Huang et al., 2010). The purpose of this chapter is to provide an overview and synthesis of how China is governing its water resources. The broad overview provides an analysis basis for the four chosen case studies in the chapters followed.

This chapter is organized as follows. The next section reviews legal environment for China's water resource management. Section three looks into institutional arrangement. Section four examines issues related to transparency, information disclosure, and public partition. The next section discusses how market-based instruments are being adopted in water resource management in China. The final section concludes the findings.

2. Improving but yet far from perfect legal environment

Over the past two decades, China has made much progress in improving its legal framework for water resource management (World Bank, 2009). The existing framework includes at least three levels: relevant stipulations in *Constitution* as the primary source of legality and authority at the first level; national laws and their implementation guidelines at the second level, such as *Water Law* (approved in 1988 and amended in 2002), *Water Pollution Prevention and Control Law* (approved in 1984 and newly amended in 2008), *Water and Soil Conservation* Law (approved in 1991), *Flood Control Law* (approved in 1998), and *Fishery Law* (approved in 1987 and newly amended in 2004); and at the third level national and sectoral administrative regulations on water, such as *Regulations on River Channels* and *Regulations on Flood Prevention*, and local regulations and rules that have played a critical role in regional water management (World Bank, 2009).

However, many studies (e.g., Varis and Vakkilainen, 2001; Cai, 2008; World Bank, 2009) have stated that the legal framework for water resource management in China leaves much room for improvement. Below are summarized main weaknesses and areas for improvement.

1) Incomplete legal system

The newly amended *China Water Law*, for example, provides codes for water allocation and use, but it does not clearly define water use rights. Therefore, both its identification and supervision are heavily manipulated by the powerful water bureaucracy. When there is conflict emerged related to water rights, it is usually handled by administrative measures as individual cases, following some government guidelines. The water use rights system is therefore often subjected to high transaction costs and social and/or economic losses with the two sides involved in water transfer.

The Water Pollution Prevention and Control Law, as another example, requires that the state establish and improve compensation mechanisms for ecological protection of the water environment in drinking water source areas and upstream of rivers, lakes, and reservoirs by instruments such as payment transfers, but there are no supporting national laws or regulations in support of ecological compensation in river basins.

2) Lack of detailed mechanisms and procedures

Existing laws and regulations usually are focused on general principles and lack detailed mechanisms and procedures for enforcement, such as supervision, monitoring, reporting, evaluation, and imposition of penalties against violators. The newly amended *Water Pollution Prevention and Control Law*, for example, includes stricter penalties against non-compliers, but effective implementation of those measures remains a question without more detailed guidelines to implement the law.

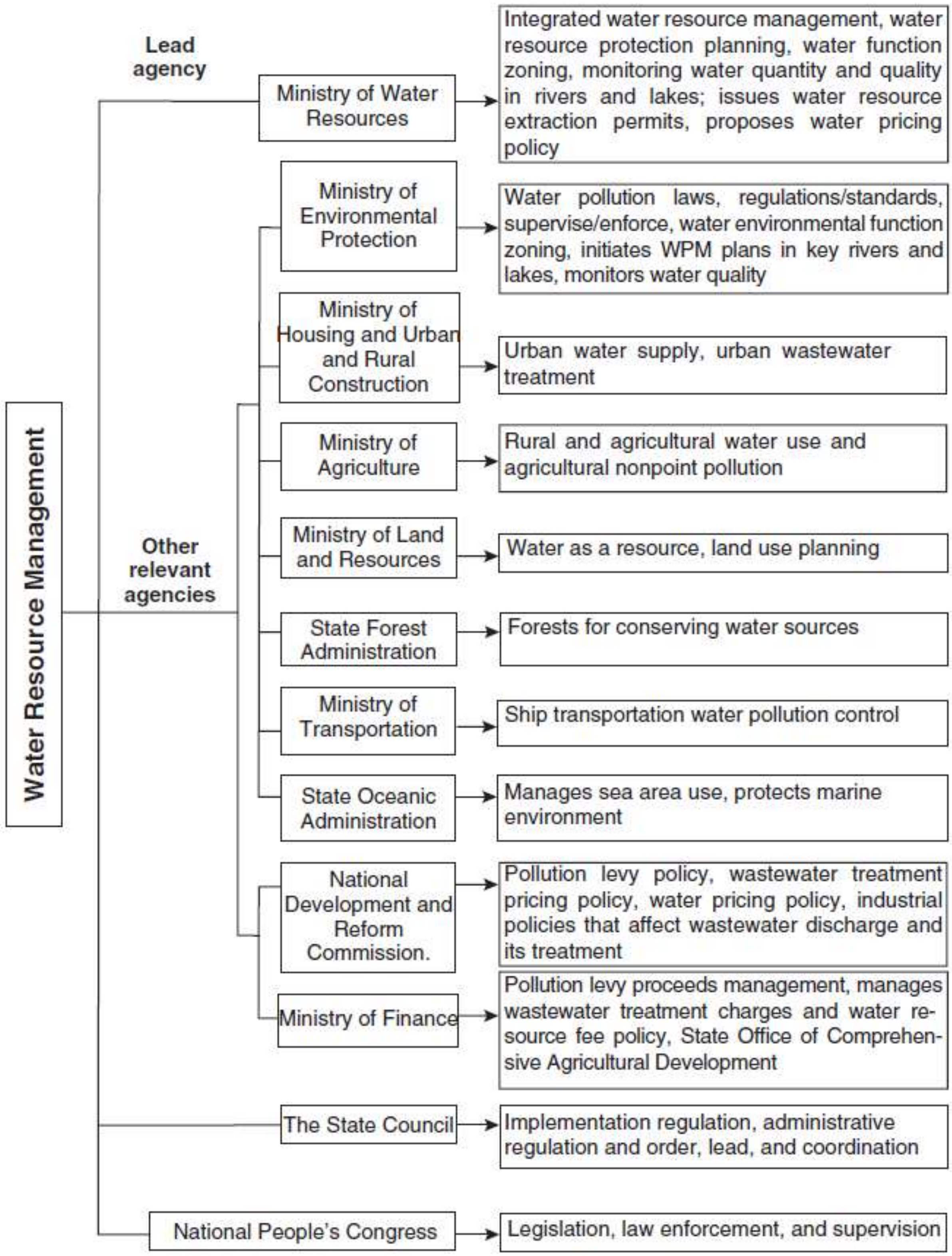
3) Ambiguous legal provisions

The Water Law, for example, does not clearly define the authority of the local governments and the river basin management commissions (RBMCs). Neither does it clearly demarcate the authority of environmental protection agencies versus the role of water administrative organizations in aspects of water management, such as water quality monitoring. These ambiguous legal provisions often lead to overlap or vacuum in responsibilities. In addition, the *Water Pollution Prevention and Control Law* defines the responsibilities and duties of local government in water environmental protection, but does not provide financial arrangements for local governments assuming the responsibilities.

3. Evolving from fragmented to integrated management

China's institutional system of water resource management used to be notoriously fragmented, involving multiple government agencies both at vertical levels and at horizontal levels. From top to bottom, there are at least five-tiered administrative structure including the national (i.e. National People's Congress, the State Council, and multiple Ministries), provincial, municipal, county, and township. At each level there are at least ten government agencies related to water resource management with the Ministry of Water Resource (MWR) as the lead agency and nine other relevant agencies (see Figure 6). All these agencies have different responsibilities which may sometime overlap or even conflict with each other.

Figure 6: Key decision makers in China's water resource management



Source: World Bank (2009)

In the current water management system, for example, multiple agencies are responsible for water quality monitoring and management including Ministry of Environment Protection (MEP), MWR, Ministry of Housing and Urban and Rural Construction (MHURC), and Ministry of Health (MOH). Both MWR and MEP monitor the water quality of major rivers. MWR is interested in both water quality and water quantity with a focus on the overall water quality of rivers, while MER is responsible for water quality only with a focus on pollution control at the source. Each agency has its own monitoring equipment and stations and water quality data from the two are sometimes inconsistent (World Bank, 2009). Neither do they share its respective database on water quality information, which sometimes lead to coordination difficulties in water management or even organization conflicts (Miao, 2006).

The responsibility for water pollution prevention and control is also broken down and put under different institutions. While MEP is responsible for prevention and control of pollution from industrial and municipal sources, Ministry of Agriculture (MOA) is responsible for nonpoint agricultural pollution control and Ministry of Transportation (MOT) for ship transportation water pollution control. Consequently, for any given water body that receives pollution from various sources, the management of water quality has to simultaneously involve all these institutions as well as MWR. This increases the difficulty and administrative costs in water quality management.

Just as what numerous scholars recommend (Hufschmidt and Tejwani, 1993; Ongley and Wang, 2004; World Bank, 2009), China's water resource management is approaching to increasingly integrated management after a series of recent policy reforms and institutional restructure. One example is the revised *Water Law* of 2002, which aims to extend the MWR's powers and to change the status quo of "too many dragons struggling over the waters." Another example is the rising power of River Basin Management Commissions, which are responsible for preparing basin-wide water allocation plans and providing technical direction and guidance to local governments within the basin. As of today, China has established river basin management commissions (RBMCs) for its seven large river/lake basins (six river basin management commissions and the Tai Lake Basin Management Agency) as subordinate organizations of the MWR (see Figure 7). Another notable example is the newly establishment of water service bureaus which have sought to integrate water management in many Chinese urban areas.

Figure 7: Layout of river/lake basin management commissions in China

Source: Adopted from Feng (2009)

However, conflicts continue even now between ministries since by its nature water cannot be treated as if it were one single and independent issue domain. River basin commissions under the MWR monitor water quality in the rivers but have no authority over its control, despite being given expanded powers under the revised *Water Law of 2002*. Unlike river basin commission in the United States, RMBCs in China have no representatives from the affected provinces and municipalities. As a result, it is difficult for them, as subordinate institutions of MWR, to coordinate with related provinces/municipalities and other stakeholders. For example, the Yellow River Commission oversees the allocation of withdrawal quotas among provinces, but has no power to prevent a province from exceeding its allocation.

4. Improving but yet satisfactory transparency, information disclosure and public participation

Transparency, information disclosure, and public participation are all indispensable elements of good governance. It is believed that the overall legal framework in China has been much improved in past two decades for promoting and protecting the legal rights of public participation in water resource management. The Environment Impact Assessment Law, for example, was passed in 2003, which specifically articles on public participation in the formulation of governmental plans and the design of construction projects.

Central governmental agencies and local governments both have also promulgated regulations and policies to promote water-related information disclosure and to facilitate public participation. For example, the MWR issued the Guidance for Further Enforcing

Openness of Administrative Affairs (GFEOAA) for Water Management in 2005 and the Provisional Regulation on Openness of Administrative Affairs in 2006. The MEP promulgated the Provisional Regulation on Public Participation in Environmental Impact Assessment in 2005, the Regulation on Public Hearings for Administrative Permits in Water Sector and the Regulations on Water Withdrawal and Collection of Water Resource Fees in 2006, and Environmental Information Disclosure Decree in May 2008.

The water users association (WUA), mostly in the form of farmer WUAs, has recently become a very popular form of public participation in water resource management in rural China. As early as October 2005, MWR, NDRC, and the Ministry of Civil Affairs (MCA) jointly promulgated the Guidance for Facilitating Establishment of Farmer Water Users Association, specifying principles and procedures for establishing such associations and their role and responsibilities in relation to governmental organizations and water supply enterprises. According to MWR, there are over 4,000 water user associations which have been founded nationwide in 2004 and the number increased up to over 7,000 in 2005 and over 20,000 by mid of 2007. A majority of WUA farmers stated that WUAs can in somewhat safeguard farmers' interests, decrease frequencies of disputes over water, reduce irrigation costs, and encourage efficient water uses (Qiao et al., 2010).

Despite of the progress above, there are still many areas for improvement. Information on water quality, for example, is not only easily inaccessible to the public, but also inaccessible to other governmental organizations outside those sectoral or local government organizations. Although prescribed in laws or regulations, the activities of public participation are often deliberately or unconsciously distorted in practice. In such forms of public participation as public hearings and expert assessments, some organizers tend to select those in favor of the views or interests of the organizers, rather than to select true representatives of stakeholders and experts (World Bank, 2009).

5. Increasing adoption of market-based instruments

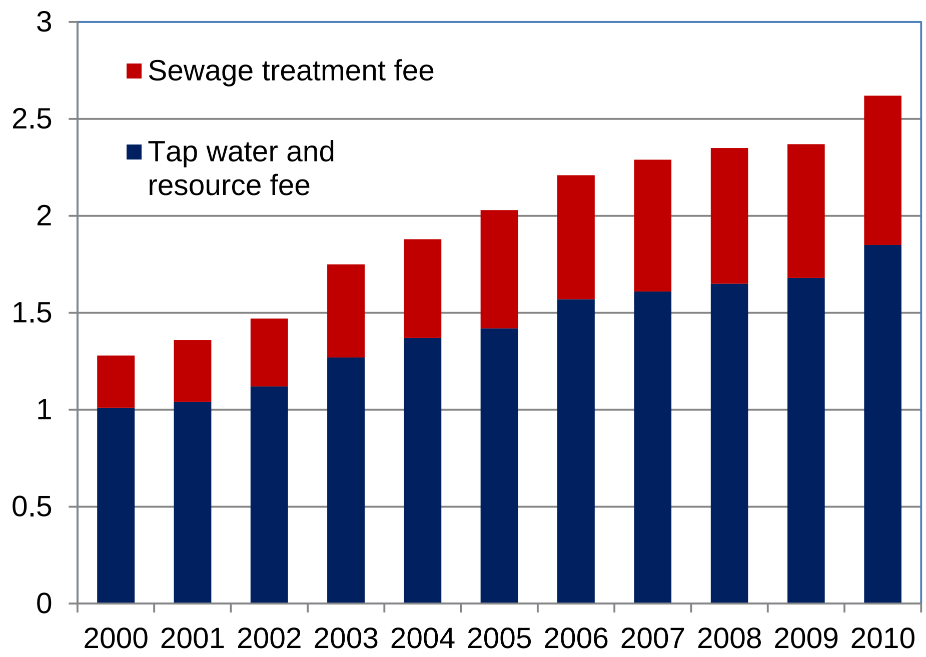
The use of 'command and control' regulations has dominated the practice of water resource management in China for decades. However, being aware of a strong need for efficient water use, China has begun to adopt market-based instruments such as water pricing, water market, water rights transfer and trading, etc.

Water prices in China, for example, are determined politically and by top-down administrative commands rather than by the market. China's NDRC, the country's top planning agency, issues regulations and provides general guidance on water pricing, but enforcing those regulations is generally left to local governments and the service providers (most are now state-owned water companies). Key involving government agencies include local NDRCs, local MHURCs, and local Price Bureaus for urban water prices and local Water Bureaus and local Agricultural Bureaus for agriculture water prices.

The NDRC issued a regulation on water pricing in 2006, capping certain expenditures and stipulating what should be covered in the rates charged to consumers. Under this regulation, water prices in China include three components consisting of water resource fee, tap water fee (the cost of tapping the water resources, providing the running water, and constructing the infrastructure required for delivery), and sewage treatment fee.

It has been believed that Chinese government authorities have intended to endorse full-cost pricing as an effective tool for managing demand and promoting efficient water use (Zhong, et al., 2010). In urban China over the last two decades, major advances have been made in increasing the water tariff of an initially free natural source. The average of water price in 36 key Chinese cities, for example, has almost doubled from 1.28 to 2.59 Yuan per cubic meters (see Figure 8).

Figure 8: Average residential water tariffs in major 36 Chinese cities (RMB Yuan/m3)



Data source: price.Ho2-China.com

Many Chinese cities are now planning more water price increases in the near future. Shanghai, for example, raised residential water prices 25 percent last June and plans another 22 percent increase this November. The central city of Zhengzhou raised water fees 25 percent last April, and officials say prices will have to change more rapidly in the future. The current residential rate for water in Beijing is 4 Yuan per cubic meter, which is the highest in China and more than 30 times the 1991 price of 0.12 Yuan, and the rates for other sectors are much higher (see Table 4).

Table 4: Water price in Beijing, by July 2010 (unit: Yuan/cubic meters)

	Tap water	Water resource	Sewage treatment	Total
Residential	1.70	1.26	1.04	4.00
Municipal	2.80	1.32	1.68	5.80
Industry	3.00	1.44	1.77	6.21
Hotel and restaurants	3.50	1.16	1.55	6.21
Special industry (e.g. Salon)	58.90	21.10	1.68	81.68

Data source: price.Ho2-China.com

However, China's water prices do not yet reflect the full cost of water treatment, sewage, delivery, tapping the water source, and the value of the water itself. Capital costs, meanwhile, continue to be subsidized by the central government. China's water prices are still low by global standards. Average water prices in Europe are anywhere from four to 10 times higher (Batson, 2009). More discussion on China's urban water pricing could be found in the water pricing case in chapter five.

Compared to under-priced urban water, the record on water pricing in agriculture is even worse (Wang et al, 2005; Cai, 2008; Huang et al., 2010). Although water officials increasingly emphasize the need to increase water prices to encourage irrigation water savings, there has been little progress up to date. In China, most farmers pay for water on per unit of land basis, since volumetric pricing is difficult due to many physical factors, particularly the small scale and fragmented nature of China's farms. In addition, tax reform policies that seek to eliminate taxation on rural households have been implemented during the past decade. With such a policy environment, there will be strong resistance against any policy that results in lower rural incomes. Consequently, the use of water prices to motivate improvements in farm-level water management is quite rare in China. Another huge concern is that raising the price of water negatively affects crop production and put threats on China's food security.

6. Summary and conclusions

China is undergoing four major governance changes on water resource management.

First, China has made much progress in improving its legal framework for water resource management not including codifying new laws and amending existing laws but also issuing related administrative regulations and policies. The legal framework, however, has yet much room for improvement in terms of completeness, operationally, and clarity.

Second, China is evolving from fragmented water management often called as "water governing by multiple dragons" to an increasingly integrated approach which is reflected both in the rising power of river basin management commissions and in the creation of one integrated water authority at provincial levels in charge of all water related issues. This shift to integrated management is something that many studies recommend, and it probably is a good trend for China. However, conflicts continue even now between ministries and it still remains challenging for China to further streamline the fragmented water management system.

Third, although far yet satisfactory, China has made much progress in disclosing public information such as water quality data and facilitating public participation, which is both reflected in promulgating related laws and regulations and in helping establish grass root organizations such as water users associations.

Last, China is gradually shifting from engineering-dominated water management to water efficiency focused approach by adopting more market-based instruments such as water pricing and water rights transfer. For example, water pricing has evolved from a regime where water was almost free to one, today, where in most urban cities prices are high enough to cover, at least, the operation and maintenance costs of most water supply utilities.

IV. Case study: development of synthetic oil from coal in China

1. Introduction

Converting coal to liquid fuels, a chemical process often referred to as coal liquefaction or CTL, allows coal to be utilized as an alternative to oil. Its biggest benefit is to enable countries to access domestic coal reserves and to decrease reliance on oil imports, improving energy security while meeting growing transportation fuel demands. There are two major approaches for using coal to produce liquid fuels: direct coal liquefaction (DCL) and the Fischer-Tropsch (F-T) processes, also called indirect coal liquefaction (ICL). In DCL the coal is directly contacted with a catalyst with added hydrogen at elevated temperatures and pressures. By contrast, the ICL process consists to two major steps: 1) gasification to produce a synthesis gas and 2) conversion of the gas to a liquid by synthesis over a catalyst in a F-T process. Therefore, the label ''indirect'' refers to the intermediate step of first making syngas. It is generally believed that DCL processes are more efficient than ICL processes, 60% compared to 50-55%, but higher quality coal and a more complicated process is required for DCL (Williams and Larson, 2003; Liu, 2005).

Both processes were developed in pre-World War II Germany and both were used, but on fairly small scales, to meet Germany's and Japan's wartime needs for fuel (Liu et al, 2010). Since the end of World War II, the only commercial experience in F-T coal liquefaction production has occurred in South Africa under government subsidy, although many other countries show active interests on coal liquefaction technology including China, the USA, India, Japan, Australia, Botswana, Germany, Indonesia, Mongolia, and Philippines, particularly the first three key countries with large coal reserves but limited reserve of oil (Couch, 2008).

With its rapidly growing demand for transportation fuels, scant domestic oil and natural gas resources but abundant coal, China has been actively pursuing research and development (R&D) of coal liquefaction technology in past decades and currently has the most active coal liquefaction programme in the world (Fletcher , et al, 2004; Nolan, et al., 2004; Liu et al, 2010). For example, China is developing the world's first and the largest DCL plant since WWII and the largest ICL plant after Sasol, South Africa, as well several small-scale demonstration ICL plants (Liu et al, 2010). The DCL project in Inner Mongolia by China's largest coal mining group, Shenhua Group Corporation Limited (Shenhua Group in short hereinafter), has already launched trial production in early 2010 and the feasibility study of the ICL project has also been completed in the same year (Shen and Stanway, 2010).

The central government support for this industry, however, has been highly uneven and volatile as government's priorities have changed over time. Beijing has been attempting to cool off the country's coal liquefaction frenzy since the middle of 2006. The government's top planning apparatus, the National Development and Reform Commission (NDRC) issued an order in September of 2008 that all CTL projects except two operated by Shenhua Group should be suspended before receiving official approval (China Daily, 2008a; China Daily 2008b). Since then, there emerge more voices of doubt on the development of coal liquefaction in China (Zhang, 2008; Lv, 2010), most of which focus on the industrial risks and environmental concerns including water.

There is an extensive literature on coal liquefaction technology (e.g. Williams and Larson, 2003; Couch, 2008; Li et al. 2008; Tang, 2010; Liu et al., 2010) and a few discuss from policy perceptive the driving forces and barriers in the development and implementation of coal liquefaction in German (Vallentin, D., 2008a) and the United States (Vallentin, D., 2008b). Nolan, et al. (2004) analyzes China's move to coal liquefaction focusing on energy security.

Yet factors other than energy security that have pushed and enabled China to go coal liquefaction and circumstances under which China has changed its policies on the industry are not well understood. How has China risen and become a worldwide leader today on coal liquefaction technology? Why did China transform its coal liquefaction policy so quickly in late 2006? What role is coal liquefaction going to play in China's future energy profile? To address these questions requires a review of development and current status of China's coal liquefaction industry and a deep analysis of the circumstances under which the central decisions are made and the different roles from shareholder perspective that all important players have helped shape the industry including not only the central government but local governments and the coal industry. In addition, the coal liquefaction case is well suited to analyze resource governance questions (involving multiple resources including not only coal but oil and water as well), which could help us better understand how China has managed its natural resources and governance challenges that China is facing.

This chapter is organized as follows. Section two reviews four major development phases of China's coal liquefaction industry, as well as key related industrial policies. The next two sections analyze why China go coal liquefaction and how China is able to become a worldwide industrial leader. The section five turns to disclose why China has decided to cool down the coal liquefaction industry. The final section concludes the findings and the possible role of synthetic oil from coal in China's future energy profile.

2. Development and current status of China's coal liquefaction

1) R&D initialized and suspended (1950s to 1967)

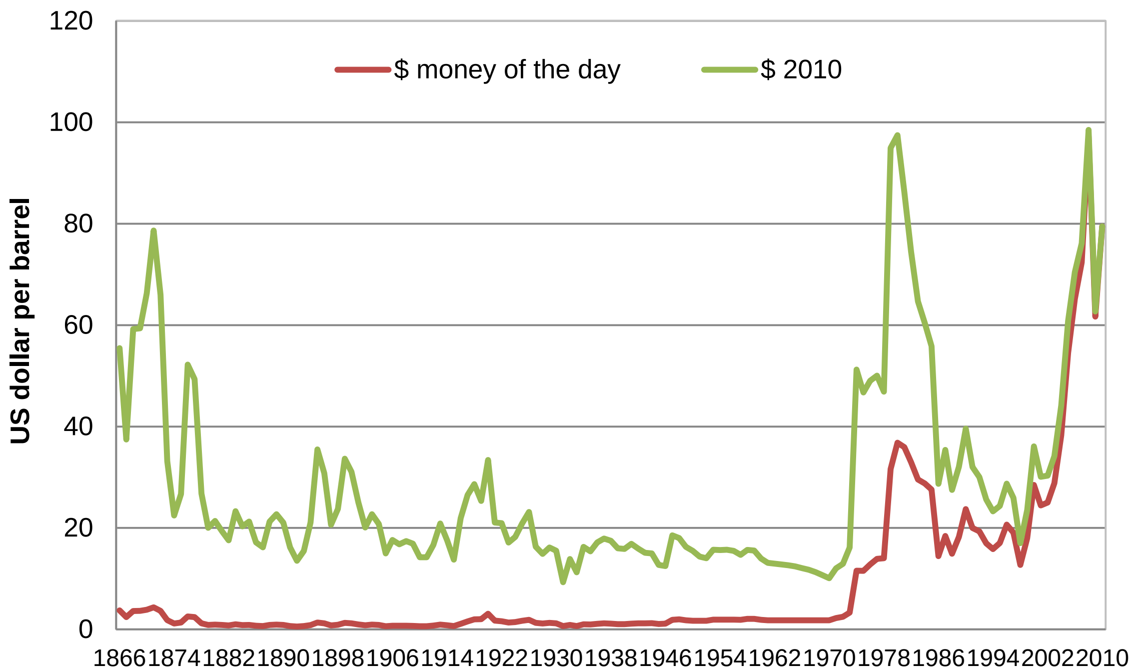
China started its research and development (R&D) on synthetic oil as early as 1930s. During World War II, Japanese established an indirect coal-to-liquids plant in Jinzhou, Liaoning Province, adopting Germany's wartime technology and started its operation in 1943 with an annual fuel output of 100 tons. The plant was suspended after the surrender of Japan in 1945. China resumed and expanded the Jinzhou plant shortly after the founding of the People's Republic of China (PRC) in 1949. The plant became operational in 1951 and achieved its maximum annual fuel output of 47,000 tons in 1957 (Tang, 2010).

However, China suspended its R&D soon after the discovery of Daqing field. In 1959 vast reserves were discovered in Songhua Jiang-Liao basin in northeast China and the milestone Daqing oilfield became operational in 1960. It was producing nearly 2.3 million tons of oil by 1963 and continued to lead the industry through the 1970s. Further important discoveries, including the major oilfields of Shengli in Shandong and Dagang in Tianjin, enabled China to meet domestic needs and eliminate nearly all imports by 1965 (Lim, 2009). The Jinzhou plant was therefore losing its strategic position and officially suspended its operation in 1967 (Tang, 2010).

2) Interests revived (late 1970s to mid of 1990s)

China's R&D on synthetic oil was resumed in late 1970s, boosting by dramatically increasing oil prices seen in the two oil crisis occurred in 1973 and 1979 (see Figure 9), respectively, and also beneficial from the gradual recovery from the Cultural Revolution ended in 1976. The research efforts had been led by Shanxi Institute of Coal Chemistry, Chinese Academy of Science (ICC/CAS), and help established China's own intellectual property on the F—T process of coal liquefaction technology. Meanwhile, China has also started its direct coal liquefaction experiments in early 1980s, which was led by China Coal Research Institute (CCRI) (Liu et al., 2010).

Figure 9: Crude oil prices 1949-2010



Data source: BP (2011)

3) Strong government support provided (mid of 1990s to 2006)

Since the middle 1990s, the central government has channeled huge support on synthetic oil including not only a series of supportive policies but also billions of government funding (see Table 5). Support, for example, has notably included the 1998 "Coal Replacing Oil Fund" of 11 billion RMB Yuan (US$1.3 billion) provided to China's first and world's first direct coal liquefaction plant, namely Shenhua direct coal liquefaction plant in Ordos, Inner Mongolia (Chu, 2008). Coal liquefaction technology is supported by all major national science & technology programs including *State High-Tech Development Plan* (or simplified as *863 Plan*), *National Key Basic Research Program* (or simplified as *973 program*), and CAS's *Knowledge Innovation Program (KIP)*. The strong support is mostly driven by Beijing's growing energy security concern — China became a net oil importer in 1993 and the share of imported oil has been continuously rising and also aligned with the country's conscious plan to shift more development west (called "Western Development" or "the Great Leap West") (see more discussion on these two major drivers in section 3).

Table 5: Key milestones indicating Beijing's attitude on the development of coal liquefaction technology and industry

Attitude	Time	Programs/regulations
Supportive	1986	Included in *State High-Tech Development Plan* or simplified as *863 program* initialed by the MOST
	1997	The State Council issued *The 9th Five-Year-Plan for Chinese Clean Coal Technology and the Compendium of 2010 Development* • Was placed as one of 14 key technologies to develop • A commercial coal liquefaction plant by 2010
	1997	Included in *National Key Basic Research Program* or simplified as *973 program* initialed by the Minister of Science and Technology (MOST)
	1998	"Coal Replacing Oil Fund" of 11 billion RMB Yuan (US$1.3 billion) provided to the Shenhua Group's DCL plant
	1998	Included in one of 19 key projects in CAS's *Knowledge Innovation Program (KIP)*
	October 2006	The MOST released *National 11th Five-Year Science and Technology Development Plan* • Was placed as one of prior developing technologies • Included into the list of key technologies and product catalogs that China should have independent intellectual property rights
Cautious	June 2006	Primer Wen Jiaobao warned during an inspection tour in Shenhua's DCL plant that enterprises should not rush to commercialize the CTL projects blindly before the test projects are proved successful.

July 2006	The NDRC (formerly the NDPC) issued *Notice on Strengthening of Coal Chemical Industry Projects to Promote the Healthy Development of the Industry* • In principal, no approval for any CTL project with an annual fuel output below 3Mt • Responsible government agencies must temporally suspend any new project review before the completion of the Compendium of National Coal Liquefaction Development
August 2008	The NDRC issued *Notice on Reinforcing the Management of Coal Liquefaction Projects* • Restated that the CTL industry was still in an experimental stage • All coal liquefaction projects except two involving the Shenhua Group should be stopped
September 2009	Ten Ministers/Agencies jointed issued *Advices on Avoiding Problems of Overcapacity and Duplication to Guide the Health development in Certain Industries* and the State Council approved and forwarded it later • Restated that the industry is still in demonstration phase • In general, no more new projects within three years • Implementing local official accountability
April 2011	The NDRC issued *Notice on Regulation on the Coal Chemical Industry to Achieve the Orderly Development* • Ban any coal liquefaction plant with an annual fuel output 1 Mt and below • All demonstrations are required by the document of NDRC • Strictly regulate the coal chemical projects with high water consumption be constructed in water-stressed areas • In principal, one demonstration project only for one company

Source: The State Council of China (1999); The Minister of Science and Technology of China (2006); China Daily (2008a): NDRC (2006); NDRC (2008); NDRC (2011); the State Council of China (2009);

4) Cool down by the central (2006 to present)

With huge support from the central government, as well as from coal-rich provinces and major coal companies, synthetic oil technology has gradually moved from laboratories to pilot or demonstration plants. By 2006, almost all provinces or regions with some coal reserves had shown huge enthusiasm on coal liquefaction (see more discussion on section 5.2).

Beijing's attitude on coal liquefaction, however, has changed since the middle of 2006 (see Table 1). Shortly after Primer Wen Jiabao warned the risks of blindly rushing into the commercialization of the CTL projects, the NDRC issued its first regulation notice on the coal chemical industry on July 7, 2006. The notice urged for the "healthy development" of the CTL industry and required local governments not to approve any CTL project with an annual fuel output below three million tonnes and to temporally suspend any new project review. The NDRC stated that the CTL project was still under a demonstration phase and should only be promoted nationally after successful demonstrations. The construction frenzy, however, showed no signs of abating.

Since then, the NDRC issued three more project suspension notices (see Table 1). In August 2008 the NDRC ordered all coal liquefaction projects except two involving Shenhua Group (the direct coal liquefaction plant in Inner Mongolia and the indirect one in Ningxia Hui autonomous region) should be stopped. Most recently in early 2011, the NDRC issued another circular banning any coal liquefaction plant with an annual fuel output below one million tonne and also requiring to prioritize coal supply to residential use and power generation and banning land use and banks loans to those coal chemical projects which do not meet industrial policies and regulations. Due to tightened industrial policies, many coal liquefaction projects were called off such as Shenhua/Sasol in Shannxi, Yunnan Xinfeng Coal Chemical Group in Yunnan Xunxun, Shandong Energy Group in Xinjiang Yili, and China Pingmei Shenma Group in Henan Pingdingshan.

5) Current development status

There are currently eight coal liquefaction demonstration projects that have potential to run commercially in China, with a total annual oil capacity of 38.2 million tonnes and an estimated total investment of 380 billion RMB Yuan (about US$58 billion) (see Table 6). Major Chinese enterprises that have been involved in coal liquefaction projects include Shenhua Group, Inner Mongolia Yitai Group (Yitai Group), Shanxi Luan Group (Luan Group), and Yankuang Group. It is estimated that the total oil capacity of coal liquefaction projects in construction or under planned are at least 38.2 million tonnes with the total investment costs at least 380 billion RMB Yuan (about US$58 billion) (Xie, 2011).

Table 6: Major coal liquefaction projects in operation or under planned

Affiliation	Type	Capacity (million tonnes/year)	Location	Construction time	Operation time
Shenhua	DCL	1 (5[a])	Inner Mongolia	2004	2008
Yitai	ICL	0.16 (0.48[a])	Inner Mongolia	2006	2008
Luan	ICL	0.16 (0.48[a])	Shanxi	2006	2009
Yankuang	ICL	1 (5[a])	Shannxi	Under plan	-
Shenhua-Ning/Sasol	ICL	3.2 (6 [a])	Ningxia	Under plan	-
Shenhua	DCL & ICL	3	Xinjiang	Under plan	-
Chongqing Yufu	ICL	5	Guizhou	Under plan	-

[a] Number in parentheses: planned expansion capacity in near future.

Source: Wang and Gao (2009); Xie (2011); Zhen and Cai (2011); Ruan (2011); Chen (2011) and Tan et al. (2011).

Shenhua's direct coal liquefaction project in Inner Mongolia started its construction in 2004 and accomplished its first trial operation at the end of 2008. It was reported that the project produced 216,000 tons of refined oil products in the first quarter of 2011, which brought more than 100 million RMB Yuan (US$15.4 million) in profits. In 2010 the pilot project operated for 5,000 hours and produced 450,000 tons of oil products (Zhen and Cai, 2011). Shenhua's indirect coal liquefaction project in Nixiang, a joint venture with Sasol, has recently got the pass from the Ministry of Environmental Protection (MEP) and is waiting for the final approval from the NDRC (Ruan, 2011). Shenhua's another indirect coal liquefaction project with Shell in Shannxi, however, was already suspended in 2009 after Beijing issued multiple projection suspension warnings (Wang and Gao, 2009). At the end of 2010, Shenhua Group announced its new plan on both direct and indirect coal liquefaction plants in Xinjiang Uyghur Autonomous Region, a region having 40 percent of China's total coal reserves. The move is to establish the biggest coal liquefaction base in China with an estimated annual fuel output of three million tonnes (Tan et al., 2011).

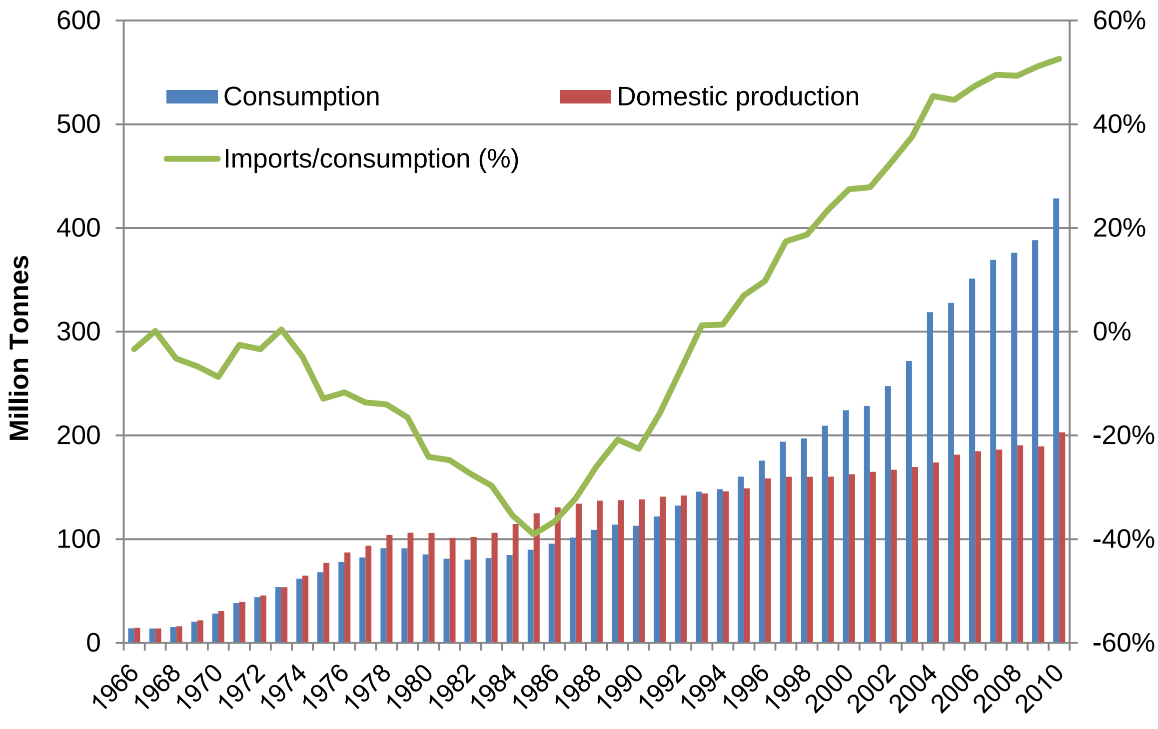
Luan's ICL project in Shanxi and Yitai's ICL project in Inner Mongolia accomplished their first trial operation in 2008 and 2009, respectively and both have achieved a long period of stabilized operation (Chen, 2011). Yankuang's ICL project in Shannxi, however, is still waiting for the approval from the NDRC after it got the pass from the MEP in 2009 (Ruan, 2011). In addition, Guizhou province is planning to build an indirect coal liquefaction project with an annual oil capacity of 5 million tonnes with a total investment of 75 billion RMB Yuan (about US$12 billion) (Xie, 2011).

3. Major drivers: energy security and western development

1) Energy security

Energy security is the single most important driver for China to go coal liquefaction (Nolan 2004; Liu et al., 2010). Back in 1949, the domestic oil output in China was merely 0.12Mt (Lim, 2009). The oil embargo initiated by western countries during the Cold War taught China the first lesson of the importance of energy security. Since then, China had to heavily rely on imported oil from the Soviet Union and Eastern Europe. But the sudden Sino–Soviet split in the early 1960s and the cutoff of oil supplies by the Soviet Union made China feel for the second time the plight of oil shortages (Leung, 2011). After being self-sufficient for nearly 30 years, China became a net oil importer in 1993 (see Figure 10) and energy security concern rose sharply since then. Today, China is the world's second-largest oil importer, only behind the US. The share of imported oil among total domestic consumption has increased up to 53 percent by 2010. By contrast, the U.S. oil-import dependency fell below 50 percent in 2010 for the first time in more than a decade and the moderating trend is expected to continue through the next decade (Reuters, 2011).

Figure 10: China's oil dependence on foreign oil



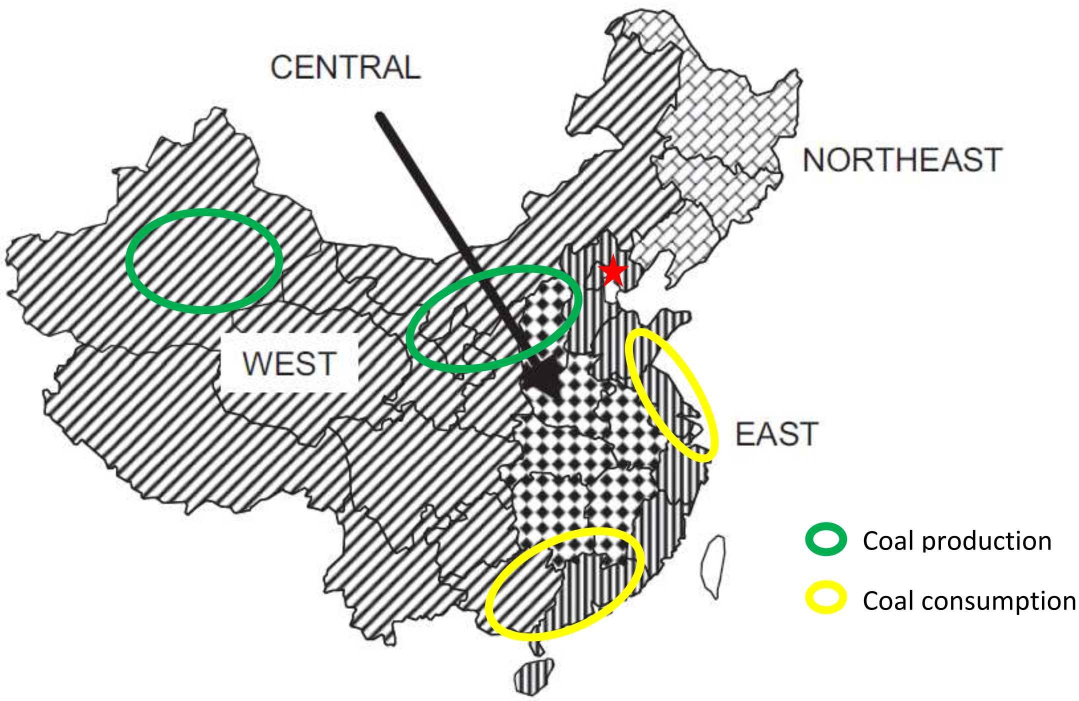
Data source: BP (2011)

2) Western development

The government's decision to put huge financial resources into coal liquefaction projects is also aligned with Beijing's interests to shift more development west (called "Western

Development" or "the Great Leap West") to balance astronomic growth in the eastern part of the country but continued poverty in the west (for a map of four regions of China, see Figure 11). Under the leadership of Deng Xiaoping, China began to reform its economy in 1978 by changing from a command economy to a market economy. The coastal regions of eastern China benefited greatly from these reforms, and their economies quickly raced ahead. Western China, however, severely lagged behind. As of the end of 2009, for example, this region contains about 71 percent of mainland China's areas, but only 28 percent of its population, and 18 percent of its total economic output (NBSC, 2010). Despite of a lower level of economic development, western China is rich in natural resources. Inner Mongolia alone, for example, has nearly one quarter of China's total approved coal reserves (NBSC, 2010) and Xinjiang's coal resources are predicted to amount to 2.19 trillion tons, accounting for 40 percent of the country's estimated overall reserve volume (China Daily, 2011). The development of coal liquefaction industry in western China serves well the aim of "Western Development": to increase the economic situation of the western provinces mainly through capital investment and development of natural resources.

Figure 11: Map of China, the four regions of China



Note: The provinces (including autonomous regions and municipalities) of China are grouped into four regions as shown in figure based on their geographical locations. West China refers to Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia, and Xinjiang.

3) Coal transport bottleneck

Another important benefit of going coal liquefaction is to develop coal resources in places where those are rich and therefore to help solve coal transport capacity bottleneck. Most of China's coal resources are located in northern and western China including Shanxi, Shaanxi, Inner Mongolia, and Xinjiang, while most of coal consumption occurs in heavily industrial eastern and southern China such as Shanghai, Zhejiang, Guangdong, and Fujian (see Figure 3). Moving coal around the country utilizes a large and growing share of domestic transport capacity. As of 2009, the rail networks, as the dominant model of coal transport in China, transported more than 1.3 billion metric tons of coal, accounting for nearly 50 percent of the total railway transport capacity (NBSC, 2010). However, this capacity has yet proved sufficient to deal with the rising coal outputs. From 2000 to 2009, for example, lengths of railways in operation in China grew only 2.5 percent annually, lower than the 7.6 percent of the annual growth rate of coal freight carried by national rail, and much lower than the 10.0 percent of annual coal production growth rate over the same period (NBSC, 2000 to 2010). It is believed that recent rising coal prices (and coal-power conflict) is partially due to the reality of insufficient or unavailable rail freight capacity supplemented by overloaded and inefficient trucks (Zhou, 2010 and Rui et al, 2010).

4. Consolidation of the coal industry: helping grow potential players for coal liquefaction

The synthetic oil industry is both capital and technology intensive, which means that any potential player in the field must be big in scale and advanced in technology. The recent consolidation of China's coal industry has greatly helped to grow those coal mining giants that are big in scale and advanced in technology, with Shenhua Group as a notable example.

1) Consolidation of China's coal industry

Dirty, inefficient, and dangerous used to be words when the outside world describes China's coal industry. However, the picture is gradually changing. Since the opening-up of market economy in 1978, China's coal industry has experienced the fastest pace of growth in the history of the world's coal industries, with production up nearly five times from 666 million metric tons in 1982 to 3,240 million in 2010, accounting for almost half of the world total (BP, 2011).

To improve efficiency and safety at the mines, the central government has restructured and reformed the industry, mainly through closure of smaller mines and establishment of modern state-owned coal corporations, such as Shenhua Group. During the 11th Five-Year Plan (2006-2010), for example, the country closed down about 9,000 small mines and eliminated 450 million tons of production on average annually (China Daily, 2011). The shares of total production of China's four largest and eight largest coal companies among the national total have increased from 10 and 14 percent in 2000 to nearly 21 and 29 percent in 2009, respectively (China Coal Industry Association, 2002-2011). These numbers, however, are still quite low compared to those of western countries. The numbers for the U.S. top four and top eight coal companies, for example, are 48 and 62 percent in the same year, respectively (EIA, 2010). To further improve efficiency and safety at the mines, Beijing believes that more consolidation is needed for China's coal industry and therefore announced the target of reducing the number of coal companies from currently 11,000 to 4,000 by 2015 (Hu, 2011).

2) Emergence of super coal mining giants

Under the big consolidation context, several super state-owned coal mining giants have emerged with Shenhua Group as a notable example (see Table 7). Shenhua Group is the largest coal company in China and the largest coal supplier in the world, accounting for more than 10 percent of China's total coal production and nearly 5 percent of the world's total. The giant state-owned coal company is the best showcase of a large, integrated, modern corporation in China with all the coal-related businesses including coal production and sales, electricity and thermal generation, coal liquefaction and coal chemicals, and railway and port transportation. By 2010, as one of Fortune 500-largest companies worldwide, Shenhua Group owns 54 coal mines with the total annual coal output hitting 352 million tons, 1,369 kilometers of dedicated railways with an annual turnover of 136 billion tons/kilometer, and power plants with an installed capacity totaling 26,817 MW (Shenhua Group, 2011). Shenhua Group has also been the epicenter of most innovation, for example, the development of a zero water discharge technology and CO_2 sequestration in its Ordos DCL plant (Bai and Stanway, 2010).

Table 7: Annual coal production of China's top eight coal companies, 2009

Rank	Coal Company	Production (million metric tons)	Market share (%)	Revenues (billion RMB)
1	China Shenhua	328	11.0%	161.2
2	China National Coal	125	4.2%	70.2
3	Shanxi Coking Coal	81	2.7%	77.5
4	Shanxi Datong	75	2.5%	42.5
5	Shannxi Coal & Chemical	71	2.4%	32.1
6	Anhui Huainan Mining	67	2.3%	35.2
7	Henan Coal & Chemical	57	1.9%	104.1
8	Shanxi Lu'an	55	1.8%	49.9
	Total top eight	**859**	**28.9%**	**572.7**

Data source: China Coal Industry Association (2011)

Shenhua's leading position in China's coal industry enables it being the most important industrial play of coal liquefaction in China or worldwide. The company was founded in 1995 under the auspices of the State Council and with Beijing's aim to build large, modern coal companies to consolidate the coal industry. As a stated-own enterprise of "China Characteristics," Shenhua Group enjoys a combination of uniquely favorable conditions which any other company may not easily clone.

First, it was granted the largest quantity of coal reserves ever granted by China's central government to a company. The total recoverable reserves of its Shenfu Dongshen coalfield are as much as 223 billion ton, accounting for more than one fifth of China's national total (Nolan, 2004). Second, the company was granted the largest ever amount of loans from the government. The central government, through the State Development Bank, granted Shenhua Group preferential lower interest-rate loans of more than US$9.2 billion from 1985 to 2005 (Rui et al., 2010). The company was also granted by the central "Coal Replacing Oil Fund" of 11 billion RMB Yuan (US$1.3 billion), which basically means the central government had granted to Shenhua Group other than other companies the strategic national mission of developing coal liquefaction. Third, Shenhua Group was granted a dedicated railway to transport its coal from its Shenfu Dongshen Coalfield to the dedicated Huanghua port. Finally, water demand for Shenhua's DCL project in Ordos, Inner Mongolia, is also guaranteed with supports from both the central and the city government.

5. Crucial concerns: natural resource constraints and local development craze

Chinese central government's decision to cool down coal liquefaction is rooted in five concerns. First, the industry is of huge business risks, characterizing by volatile international oil supply and prices (see Figure 9: in the first half 2008 the price of crude oil rose close to \$150/barrel but it dropped again close to \$40/barrel in late 2008), huge capital investment requirement (approximately 30 billion RMB Yuan or US$ 5 billion for a plant with three-million-ton annual capacity), and commercially immature technology. Second, water is increasing scare in China. Except for Guizhou in southwest China, all most all coal-rich regions in China are now subject to some degree of water scarcity. Third, coal is no longer cheap and affluent. Fourth, there are other environmental concerns such as CO_2 emissions, although this is not considered by Beijing as important as natural resource constraints. Last, perhaps what Beijing worries the most is development craze from local governments. Despite of business risks, increasing scare natural resources, and environmental concerns, local governments have been most motivated and entrepreneurial in attracting coal liquefaction investments.

1) Increasing pressure from natural resource constraints

Water scarcity

Water scarcity in China, notably in northern China, is pressing. The problem has attracted extensive worldwide attention and been covered by major media outlets such as Economist, CNN, Routers, and the New York Times (Economist, 2009; CNN, 2010; Harrison, 2010; Wong, 2011). China's water scarcity is reflected not only in quantity, which is well-monitored, but also water quality where monitoring systems and governance mechanisms are much more immature. This scarcity is not just a reflection of China's geography (dry north and wet south in general) but also a series of mismatches among population, agriculture, industrial outputs, and natural resources. For example, almost all coal-rich regions in China are subject to some degree of water scarcity (see Table 8). Shanxi Province, as a notable example, enjoys about one third of China's total proved coal reserves, but has only 0.4 percent of the country's freshwater resources and its per-capita freshwater resource is merely 251 cubic meters per person, less than one seventh of the national average and one thirtieth of the world average.

Table 8: Freshwater resources in China's top five coal-rich provinces, 2009

	Coal reserve (billion ton)	**Total water resources (billion m^3)**	**Per-capita water resources (m^3)**
Shanxi	105.6 (33%)	8.6 (0.4%)	251
Inner Mongolia	77.3 (24%)	37.8 (1.6%)	1,546
Shannxi	26.9 (8%)	41.7 (1.7%)	1,106
Guizhou	12.8 (4%)	91.0 (3.8%)	2,398
Xinjiang	14.8 (5%)	75.4 (3.1%)	3,517
Five provinces total	***237.3 (74%)***	***254.5 (10.5%)***	***1,633***
National Total	***319.0 (100%)***	***2,418.0 (100%)***	***1,816***

Data source: NBSC (2010)

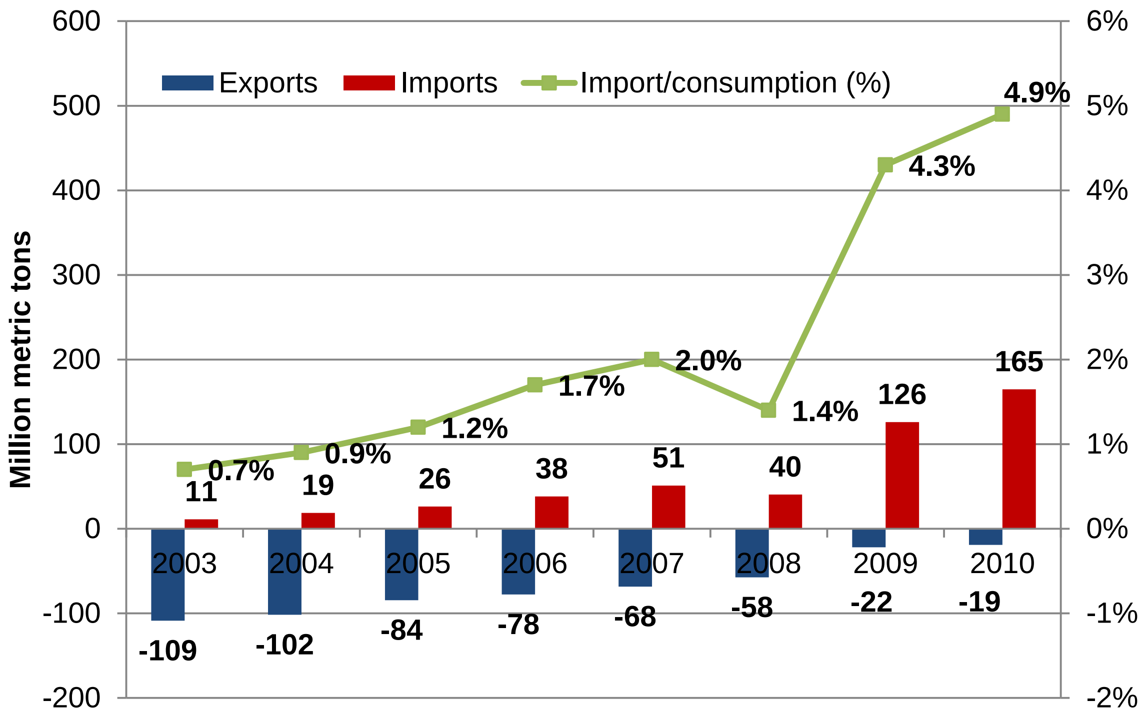
The coal-water mismatch has important implication for coal liquefaction since it is considered being highly water intensive (Mielke, et al., 2010). According to industrial data disclosed, each ton of synthetic oil output needs 8-9 tons of freshwater in DCL and 12-14 tons in ICL (Zhang, et al, 2009). The water demand for a coal liquefaction plant with five-million-ton annual fuel capacity would range from 40 to 90 million tons. This would inevitably exacerbate the problems of water availability and quality in China's coal-rich but water-stressed regions. Increasingly aware of the water problem, therefore, Beijing has tightened its CTL industrial policies since 2006 (see Table 5) and announced its strict regulation on any coal chemical project with high water consumption and being constructed in water-stressed areas.

Coal supply shortage and burgeoning prices

Coal can no longer be considered cheap and affluent in China. Compared with crude oil and natural gas, coal is relatively rich in China. However, demand for coal in China continues to dramatically increase, largely driven by the thermal power industry, and the country has experienced coal supply shortages in past three years (Leo, 2008; Rudolf, 2010). The shortages are not caused by a simple gap between supply and demand (Morse and He, 2010) but multiple complicated factors such as crackdown of small coal mines by government that are unsafe, polluting, or wasteful, a distribution mismatch between where the coal is produced and where the coal is needed (see Figure 3), inadequate domestic supplies of higher-grade coal, and price gaps between non-thermal coal priced by market and thermal coal priced by government.

Supply problems over the last couple of years have led to burgeoning imports and shrinking exports (see Figure 12). China has been self-sufficient in coal until recently (importing some coal but exporting just as much or more). But in 2009 China for the first time became a net coal importer, changing from the world's second largest coal exporter in 2003 to the world's second largest coal importer. In 2010 China imported 165 million metric tons of coal, accounting for more than one fifth of all globally traded coal.

Figure 12: China's export/import of coal, 2003-2010



Source: 2003 to 2009 data from EIA (2010a) and 2010 data from China Customs Statistics Information Centre (2011)

Supply constraints have also led to burgeoning domestic coal prices in recent years. State-controlled contract prices for thermal coal have been experiencing double digits increasing rates, rising from 137 Yuan/ton (US$17/t) in 2002 (Pan and Zhang, 2003) to currently 537 Yuan/ton ($83/t) (Xinhua, 2011). Average prices of commercial coal have soared even more, rising from 168 Yuan/ton ($20/t) in 2002 (Pan and Zhang, 2003) to currently 837 Yuan/ton (US$129) (Xinhua, 2011). Domestic coal prices have recently been higher than international ones, averagely 60 Yuan/ton higher (Pan and Wang, 2010).

It is believed that domestic coal prices still have upward pressure when the government further liberalizes coal pricing and ends government intervention (Zhou, 2010). The Chinese government has controlled domestic coal prices for decades as a way to guarantee enough cheap resources to support economic development. It shifted course in 1993 and adopted a ‘‘dual track’’ price system with non-thermal coal priced by market while thermal coal priced by government. This government intervention leads to the huge price gap between the two and is a part of roots of so called “coal-power conflict.”

Because of coal supply shortages and burgeoning prices, Beijing has to reconsider its industrial policies on coal liquefaction, since producing coal from oil is to substitute one scare natural resource with another one (once cheap and affluent but now in supply shortage and increasing expensive).

2) Development craze from local governments

Local governments attract investments for GDP growth

It was reported that ten Chinese provinces or autonomous regions, including Inner Mongolia, Xinjiang, Shanxi, Shannxi, Guizhou, Ningxia, Yunnan, Shandong, Henan and Heilongjiang, are planning or once planned CTL projects (Ren, 2009). It was estimated that by the end of 2007 taking all existing and planned CTL projects into account, China will have an annual CTL capacity of 16 million tonnes with investment planned at 120 billion RMB Yuan (US$18 billion) (China Daily, 2008a).

Because of local development craze, the NDRC centralized approval of these projects and pulled the brakes on dozens of projects. Table 2 lists three projects in operation and five under serious plan or consideration, while most were aborted during feasibility studies or even pre-feasibility studies. Several coal liquefaction projects in Yunnan Province, for example, were aborted because of the NDRC’s tightened policies. Just as Shenhua Group, Yunnan Xianfeng Coal Industry Company was initially chosen as one of three candidates to host a coal liquefaction demonstration project. The planned project had an annual fuel capacity of one million tonne with investment more than 10 billion RMB Yuan. Its pre-feasibility study was passed in 2004, but was called off by the NDRC in 2008, along with the other CTL projects in Yunnan (Tan, 2010).

The motivation behind local government officials' development craze is straightforward: they have been racing to boost regional GDP growth by putting huge investments in capital- and energy-intensive industries, since their career prospect is primarily tied to GDP growth under the current system. Over the past 20 years, China has enjoyed an annual average GDP growth of nearly 10 percent.

A resource miracle in Ordos City, Inner Mongolia

A notable example is the city of Ordos in Inner Mongolia, the host of both Shenhua's DCL project and Yitai's ICL project. Lying in the southwest of Inner Mongolia, Ordos is abundant with resources, among which the most well-known are sheep, coal, natural gas, and rare earth. For example, Ordos has 149.6 billion tons of proved coal reserves, accounting for about one-sixth of the national total. Besides its huge amount, Ordos's coal enjoys the advantages of low ash, low sulfur, low phosphorus and high heat output, thus was recognized as "clean coal" (City Government of Ordos, 2011).

Thanks to the exploitation of the region's rich natural resources, Ordos has achieved the fastest GDP growth rate in China. Statistics show that the GDP of Ordos soared from RMB 15 billion or US$1.94 billion in 2000 to RMB 264.3 billion or US$40.6 billion in 2010, averagely increasing 33 percent annually. With a thin population of less than 1.9 million, the city's 2010 GDP per capita is RMB 136,000 or US$20,800 (Ordos Bureau of Statistics, 2011), only after Macau, Hong Kong, and Karamay inXinjiang and higher than Beijing or Shanghai.

As many other cities in western China, however, Ordos has insufficient water resources to meet its rising water demand, which is largely driven by coal-related industries such as thermal power and coal chemical. Nearly 70 percent of water in Ordos is from groundwater, a share significantly higher than the national average. But the city's average exploration rate of groundwater already exceeded 60 percent (Ordos Water Bureau, 2009). Groundwater has been overexploited for years in some areas of the city, which causes serious ground subsidence (Gao et al. 2004).

The city government of Ordos has been highly "entrepreneurial" in attracting industries. To meet the water demand from the boosting industry sector, for example, the city government has been proactively pushing water transfer from agriculture to industry. During the first phase of water transfer pilot program from 2005 to 2007, the city accomplished a total water transfer of 130 million cubic meters and secured an investment up to 690 million RMB Yuan on upgrading irrigation infrastructure. The second phase of the water transfer program was launched in 2009 with a total water transfer of 100 million cubic meters and an industrial investment of 1.42 billion RMB Yuan (MWR, 2009).

Ordos built from scratch an entirely new city, called Kangbashi, of up to one million people, with the purpose of keeping the coal wealth closer to home and also partially dealing with the increasing scarcity of water. The new town is 25 kilometers from the old town, Dongsheng District, but close to rivers – the old town is chronically short of water – and to another a mining town, Yulin. The new city, however, is largely empty of people and thus called the "ghost city" of China (Chan, 2009; Batson, 2010).

Perhaps the most controversial incentive provided by the city government is so called "Black Gold" policy: attracting industries with coal reserves. In accordance with the provisions of Inner Mongolia Autonomous Region, for each new additional two- billion-RMB Yuan investment investors could receive 0.1 billion metric tons of coal up to one billion. The "Black Gold" policy makes Ordos stand up among all local cities in the race of fighting for the auto industry. Without any advantage such as human capital, transport, and supplementary industries but coal reserves (money), the city has attracted Chinese auto makers including Huatai, Chery, and Hebei Zhongxing (Fan, 2010). A notable example is Chery, China's seventh-largest auto-maker, which with its partners would jointly pump RMB 20 billion RMB Yuan or about US$3 billion into Ordos before 2015. It was reported that the Ordos government offered multiple incentives to set up a shop in the city, among which was the reported sale of a coal field, containing estimated reserves of 1.66 billion tons, to Chery at well below market price (Chen, 2010).

In the case of coal liquefaction the city government has no reservations on supporting Shenhua Group's DCL project. For example, the Ordos government decided to construct an airport to improve the local infrastructure, shortening the distance from the plant to the airport to 20 kilometers (Nolan et al., 2004). With the approval from Beijing, the city government guarantees all water usage for the project. All water is from groundwater although the city' groundwater is already overexploited.

6. Summary and conclusions

This paper makes five main arguments. First, China's central decision to put huge financial resources into synthetic oil projects is rooted in three concerns: a) growing insecurity due to dependence on imported oil; b) a conscious plan to shift more development west ("the Great Leap West," or Xibu Da Kaifa) to balance astronomic growth in the eastern part of the country but continued poverty in the west; and c) rising pressure on natural resources in addition to oil—notably coal—that have led planners to focus on developing resources in places where those are relatively untapped while also adopting more resource-efficient technologies such as advanced coal and addressing resource constraints such as availability of water. These three concerns were expressed most acutely in Beijing although each resonated with local governments (who were concerned about local employment), the coal industry (keen to advance projects that utilized coal), and other key actors.

Second, the key central decisions were orchestrated by the government's planning apparatus—notably the NDRC which oversaw development of the synthetic oil industry by providing guidance, funding, and project approvals. Support for this industry has been highly uneven and volatile as NDRC's priorities have changed over time. Today the synthetic oil industry is regarded as strategic technology and that view is likely to remain unless there are significant technological, political, or other changes.

Third, variation in political support for synthetic oil has depended in part on the status of China's domestic oil industry. Indeed, R&D on synthetic oil began in the 1950s but the government suspended it after the discovery of Daqing Field in 1959. It resumed R&D support in later 1970s, and the central government has channeled huge support since the middle 1990s. (In 1993 China became a net oil importer and oil security concerns rose sharply around this time.) Support has notably included the 1998 "Coal Replacing Oil Fund" of $1.3 billion USD (11 billion RMB Yuan) to China's first and world's first direct coal liquefaction plant. However, since 2006 the synthetic oil industry has seen four formal notices of project suspensions linked to pressure on scarce natural resources (notably water), uncertainties about the future of world oil prices and supply, sharp rises in coal prices, and concern in the central government that local governments were over-enthusiastic about development of the industry.

Fourth, local governments have been highly entrepreneurial in making use of incentives that the central government provides. Provinces and localities rich in coal have, not surprisingly, been most interested in advanced coal and synthetic oil projects. The city of Ordos in Inner Mongolia, for example, is the host of China's biggest synthetic oil project. Entrepreneurialism takes many forms. The city of Ordos government makes the best use of "black gold" policies to attract not only the coal industry but others as well. In Ordos, addressing local water constraints required the city build a totally new district closer to rivers and far from the old town where water shortages are chronic. The local government has also taken the lead in pressing the Yellow River Commission to transfer water rights from agriculture to industry.

Fifth, these projects have been shaped by the coal industry—in particular the industry's dominant enterprise, Shenhua Group, which has built the world's largest direct coal to liquid plant in Ordos, Inner Mongolia. The recent consolidation of China's coal industry has helped grow potential players, modern coal corporations, big at scale and advanced in technology. The industry has also been the epicenter of most innovation, such as in the development of a zero water discharge technology and also CO_2 sequestration.

V. Case study: urban water pricing in China

1. Introduction

China is facing severe water problems, in terms of both quantity and quality. Many studies have expressed that water prices in China are too low to encourage efficient water use and improved pricing of water supply and sewerage in both urban and rural areas could be one of important policy instruments that can help ensure that increasingly scarce water resources can be used both efficiently and equitably (World Bank, 2009; Yong, 2009; Wang, 2010).

Compared to many other developing countries, China has political will and public support for water pricing. Across China, pricing has evolved from a regime where water was almost free to one, today, where in most urban cities prices are high enough to cover, at least, the operation and maintenance costs of most water supply utilities (World Bank, 2007). Unlike electricity prices regulated by the central government, however, water prices are seen quite different across Chinese provinces and cities.

The purpose of this case is to look into how urban water prices are being set in China and whether the form of policy organization and governance ideology has a big impact on pricing. This chapter is organized as follows. The next section reviews how urban water pricing in China has evolved from almost free to relatively much higher prices today, as well key related policies and regulations. Section three explains four consisting components of urban water prices and how each component is set and regulated, respectively. Section four discloses the local difference in China's urban water pricing and further analyzes in the next section the reasons behind the difference by comparing China's two direct-controlled municipalities, Shanghai with low water tariffs and Chongqing with high water tariffs. The final section concludes the findings.

2. Evolution of urban water pricing

Urban water pricing in China has evolved from almost free when the republic was founded to relatively much higher prices today and the history can be summarized into the following four phases:

1) Free of charge (1949 – 1964)

Since the establishment of the People's Republic of China in 1949, the government has provided water to the pubic free of charge until 1964.

2) Low fees (1965 – 1979)

In 1965, the State Council promulgated *Tentative Administrative Method on Collecting and Managing Water Charges of Hydraulic Engineering*, which for the first time introduced a fee for water supply. The water rates, however, are very low and can barely cover any cost of water provision and this early attempt to price the resource was unsuccessful due to the Cultural Revolution (1966-76).

3) First wave of tariff increases (1980 – 1996)

Since 1980, China has embarked on a remarkable economic reform. This phase saw booming urban water-infrastructure investments and the rapid enactment of laws, regulations and administrative rules to promote the country's urban water reform. The State Council, for example, issued *Administrative Method on Accounting, Collecting and Managing the Raw Water Charges of Hydraulic Facilities* in 1985, which proposed to charge a fee for water that can cover operation, maintenance, depreciation, and other costs. In a major reform initiative in 1991, the responsibility of providing water and wastewater treatment shifted from central to local authorities, which established state-owned water companies through merging regional entities. In 1994, the State Council promulgated *Regulations on Urban Water Supply*, which states that urban household tariffs should be set in accordance with the principle of cost recovery and low profits. It also empowered local governments to design tariff-setting plans and procedures.

The first wave of water tariff increases took place in the mid-1980s, accompanied by installation of household water meters. By 1990, residential water tariffs are within the range of 0.15 to 0.30 RMB Yuan per cubic meters and 0.20 to 0.50 for the industrial users. Water tariffs were still far below the actual cost of water provision.

4) Moving to marketization (1997 – present)

The groundbreaking *Price Law* was passed in 1997, which gave the market the power to set prices but meanwhile retained the rights of government for market intervention. This applied to the setting of water tariffs as well. In the following year, the National Planning Commission (now the NDRC) and the Ministry of Construction (now the MHURC) issued the landmark *Administrative Method on Urban Water Supply Pricing*, which provides a legal basis for water supply pricing in China (NDRC and MHURC, 1998). The regulation particularly states that:

- the general principles of setting water tariffs are cost recovery, reasonable revenue, water conservation and social equity
- municipalities are responsible for approving water tariffs
- tariffs should cover operation and maintenance, depreciation, and interest costs
- tariffs should allow for an 8 to 10 percent return on the net value of fixed assets
- tariffs should be appropriate to local characteristics and social affordability
- a two-part tariff consisting of a fixed demand charge and a volumetric charge or IBT should be gradually adopted
- the first block of IBT should meet the basic living need of residents
- public hearings and notices should be conducted in the decision making process of setting water tariffs

A new policy *Administrative Method on Raw Water Price of Hydraulic Facilities* was promulgated in 2004, which replaced a similar one passed in 1985, labeled water for the first time as a commercial good, and thus allow higher water charges. In 2006, *Ordinance of Water Permits and Water Resource Fee Management* was issued to enable local authorities to set and keep local water tariffs. During the same year, the NDRC issued a supervisory regulation on water pricing, urging to base tariffs on the cost of supply, and also proposed *Methods on Urban Water Pricing*. The Methods, however, is still under review.

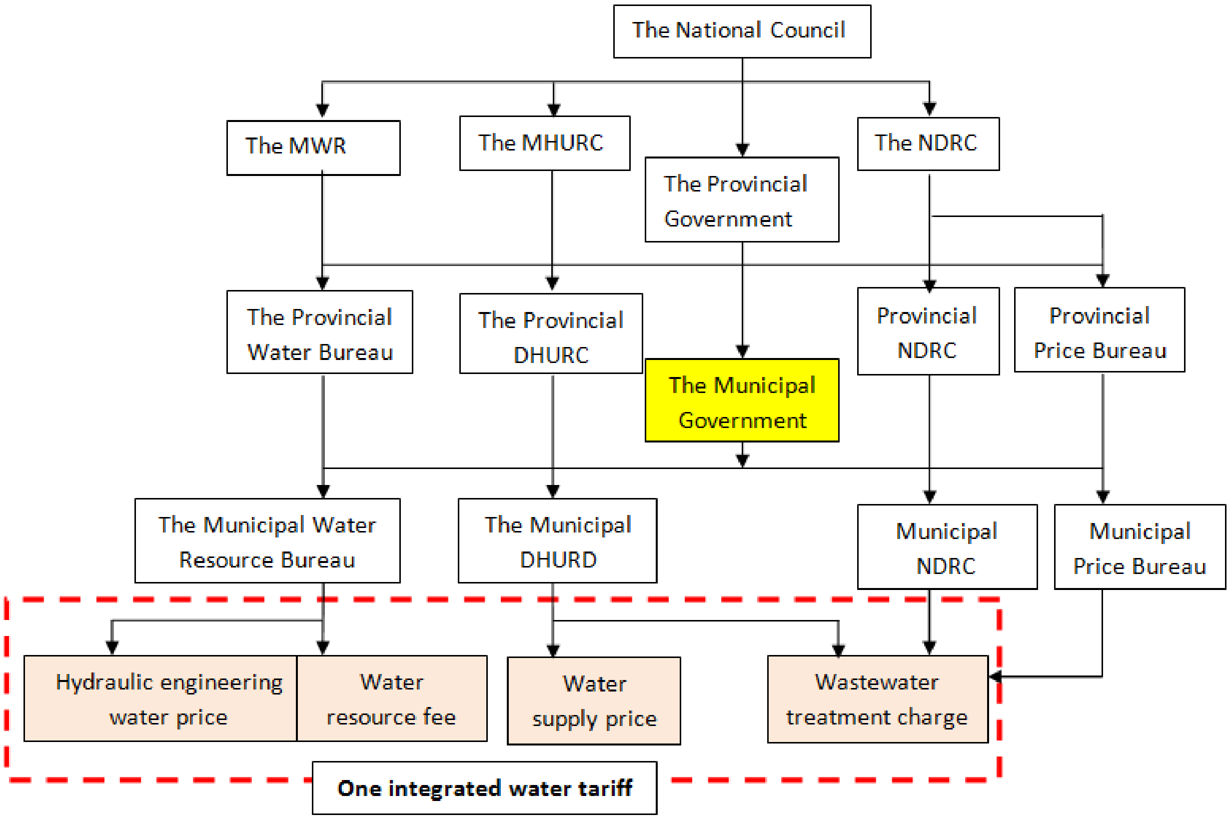
As a consequence of these policies, water tariffs in China have increased dramatically over the past decades. As Beijing an example, the residential water price including a wastewater treatment fee is now 4 RMB Yuan per cubic meter, increasing from 0.12 RMB in 1960s, 0.25 RMB in 1990, and 2 RMB in 2000 (Jiang and Tan, 2009).

3. Governance structure of urban water pricing

The water price in China now consists of four elements including hydraulic engineering water price, water resource fee, water supply price, and wastewater treatment charge (see

Figure 13). The first two elements are normally integrated into one and often called raw water price, which are set by the water resource authorities at provincial level. The last two are set and supervised by the urban construction authorities at municipal level. Water supply enterprises could propose a water price increase based on its cost structure change. However, any increase must be approved by the municipal government and the Municipal Price Bureau holds public hearings for any proposed water pricing change. Meanwhile, the NDRC provides general guidance to national water prices and the NDRC at municipal level guides the local water price.

Figure 13: Major decision players for urban water pricing



4. Urban water pricing significantly varies by locale

According to *Administrative Method on Urban Water Supply Pricing* issued in 1998, urban water prices in China are set by municipal governmental agencies, being appropriate to local characteristics (e.g. water resources) and social affordability. In theory, higher water prices are seen in income-richer but more water-stressed regions such as Beijing, Tianjing, and Shangdong Province, while lower prices should be observed in regions with lower per-capita income but richer water resources such as Xinjian, Jiangxi, and Sichuan Province. In reality, however, it is not a general rule that can be applied to the whole country.

As of October of 2010, of all 32 capital cities in Chinese provinces or autonomous regions including four direct-controlled municipalities, the average water tariff including wastewater treatment fees sits around 2.57 RMB Yuan per cubic meter for the residential users and 3.65 for the industrial users. Among all, there are eight cities with residential water tariffs higher than 3 RMB Yuan per cubic meter (see Table 9**Error! Reference source not found.**). Compared o those cities, Shanghai, as one of the richest cities in China, is not rich in water resources (mainly due to its poor water quality) but has a surprisingly lower than national average water tariff.

Table 9: Comparison between Shanghai and cities with residential water tariffs higher than 3 RMB Yuan per cubic meters

	Residential water tariff[1]			Industrial water tariff[1]			water resource per capita (m^3)[2]	disposable per capita income (RMB Yuan)[3]
	Tap	WWT	Total	Tap	WWT	Total		
Shanghai	**1.33**	**1.08**	**2.30**[4]	**2.00**	**1.70**	**3.70**	**198**	**26,675**
Beijng	2.96	1.04	4.00	4.44	1.77	6.21	206	24,725
Tianjing	3.08	0.82	3.90	5.50	1.20	7.50	160	19,423
Chongqing	**2.70**	**1.00**	**3.70**	**3.25**	**1.30**	**4.55**	**2,040**	**14,368**
Jinan	2.60	0.90	3.50	2.90	1.10	4.00	330	20,802
Kunming	2.45	1.00	3.45	4.35	1.25	5.60	614	14,482
Shijiazhuang	2.50	0.80	3.30	3.00	1.00	4.00	230	15,062
Ha'erbin	2.40	0.80	3.20	4.30	1.10	5.40	610	14,589
Ordos	2.35	0.65	3.00	3.50	0.95	4.45	1,922	20,267
National average	**1.77**	**0.80**	**2.57**	**2.65**	**1.00**	**3.65**	**2,071**	**15,781**

1. Data is as of end of October 2010 and from the database of price.H2o-China.com
2. Data only refers to local water resources in 2008 and excludes those cross-border water resources. Data for Shanghai, Beijing, Tianjing, Chongqing, and national average are from NBSC (2009) and others from various provincial water resources bulletins.
3. Data for Shanghai, Beijing, Tianjing, Chongqing, and national average are from NBSC (2009) and others from various provincial statistical yearbooks.
4. The total amount of wastewater consumed is calculated as 90 percent of water consumed.

Local water resources in Shanghai is quite limited with a level almost equal to water-stressed regions like Beijing, about 180 cubic meters per capita. Although the Yangzi River and the Huangpu River both flow along it, most of its surface water in and around Shanghai is of a poor quality. In 2009, more than 70 percent of the surface water in Shanghai is designated class 4 or worsen (class 4 is not considered drinkable) (Shanghai Water Authority, 2010).

Compared to Shanghai, Chongqing, another one of China's four as Shanghai (the other two are Beijing and Tianjin) and the only such municipality in western China, has much richer water resources and significantly lower disposable per capita income, but much higher water tariffs not only in the residential sector but also in the industry. Kunming, a capital city of Yunnan Province located in southwest China, and Ha'erbin, a capital city of Helongjiang Province located in direct-controlled municipalities northeast China, are both relatively richer in water resources, but poorer in per-capita disposable income and have higher water tariffs than Shanghai does.

Unlike electricity prices which are set and supervised by the central government, in China water tariffs are set by municipal governments, whose decisions are driven by multiple factors not only including local water resources and social affordability but other social and political issues as well. Water tariffs are regarded as one of the most complex prices in China and political events, staffing placement in water supply enterprises, changes in local consumer price index, and those policies that attract foreign investments all could directly influence how municipal governments set water tariffs (Fu, 2009). Although *Administrative Method on Urban Water Supply Pricing* issued in 1998 set the general principal that consumers should pay the costs of operation, maintenance, depreciation, and interests, municipal governments are still responsible for investing on water supply and wastewater treatment infrastructure. It is a choice of its fiscal policies for them that who share the service costs, the public or the municipal government, and how much each side does (Fu, 2009).

5. Comparison of Shanghai and Chongqing

1) General economic and social picture

Shanghai, the most populous city in China, is located at the middle portion of the Chinese coast and sits at the mouth of the Yangtze River. As a global city, Shanghai exerts its influence over global commerce, finance, culture, art, fashion, research, and entertainment. Chongqing, a major city in the southwestern China (for locations of two cities, see Figure 2), is another one of China's four direct-controlled municipalities like Shanghai, but has much a lower level of economic development and disposable per-capita income than Shanghai does (see Table 10).

Table 10: Comparison of Shanghai and Chongqing in population, land areas, Regional Domestic Product, per-capita income in 2009

	Population (million)	Land areas (km^2)	RDP (billion RMB Yuan) (Primary, Secondary, Service)				Per-capita disposable income (RMB Yuan)
Shanghai	19.2	6,341	1,505	(0.1%	19.0%	81.0%)	28,838
Chongqing	28.6	82,400	653	(9.3%	52.8%	37.9%)	15,749

Data source: NBSC (2010)

2) Water resources, demand and tariffs

Shanghai, however, has much fewer water resources than Chongqing does, not only in terms of quantity but of quality as well. Shanghai has quite limited local water resources and the per-capita water availability is merely 218 cubic meters, at the similar level as many water-stressed cities in North China like Beijing and much lower than Chongqing (see Table 11).

Table 11: Renewable water resource of Shanghai and Chongqing, 2009

	Local water resource (billion m^3)	Per-capita local water resource (m^3)	Cross-board water resource (billion m^3)	Per-capita cross-board water resource (m^3)
Shanghai	4.2	218	803	41,690
Chongqing	45.6	1,600	384	13,463

Data sources: Local water resources from NBSC (2010) and cross-board water resources in Shanghai and Chongqing are from Shanghai Water Resources Bulletin 2009 and Chongqing Water Resources Bulletin 2009, respectively.

Sitting at the mouth of the Yangtze River, Shanghai has rich cross-board water resources (see Table 11). The Huangpu River, for example, a tributary of the Yangtze River flowing through Shanghai, has supplied 80 percent of drinkable water for the local residents (Shanghai Water Authority, 2010). However, most of cross-board water resources in Shanghai, particularly those from Huangpu River, is of a poor quality. In 2009, more than 70 percent of the surface water in Shanghai including both local and cross-board is designated class 4 or worsen (class 4 is not considered drinkable) (Shanghai Water Authority, 2010). The Huangpu River has been seriously defiled by industrial wastes. Furthermore, contamination in the neighboring Taihu Lake remains a direct menace to the Huangpu River. Due to discharge of domestic and industrial sewage, high content of phosphorus in the lake has led to the occurrence of potentially toxic blue-green alga over large areas, bringing severe drinking-water problems (Hu, 2003). Therefore, unlike north China which is often afflicted with severe drought, what Shanghai lacks is quality water suitable for both drinking and industrial production. Shanghai has therefore been added to the United Nations' list as one of the six cities predicted to experience severe drinking-water problems in this century (Shao, 2004).

By contrast, Chongqing has much more ample water resources. The city is located in the upstream of the Yangtze River and has more than 40 major rivers with drainage areas greater than 1,000 km^2, for example, the Wu River and the Jianglin River. Excluding rich cross-board water resources, Chongqing’s local per-capita water availability is 1,600 cubic meters, nearly eight times of Shanghai’s. What matters the most in Chongqing is the fairly good water quality. In 2009, all water in the major five rivers within the drainage areas of Chongqing is designated as class 3 or better (Chongqing Water Resources Bureau, 2010).

Chongqing has been more water efficient than Shanghai (see Table 12). Water intensity for the agriculture sector in Chongqing, for example, is less than half of Shanghai and per-capita residential water use is approximately half of Shanghai’s.

Table 12: Water demand in Shanghai and Chongqing, 2009

	Per-capita water use (m^3)	per industrial RDP (m^3/thousand Yuan)	per-mu agriculture water use (mu/m^3)	per-capita residential water use (m^3)
Shanghai	657	1,402	524	121
Chongqing	299	1,379	239	64

Data source: NBSC (2010)

Despite of richer water resources and lower personal income, people in Chongqing have to pay significantly higher water tariffs than those in Shanghai. As of October 2010, the water tariff for residential users in Shanghai is 2.3 RMB Yuan per cubic meter, compared to 3.7 RMB Yuan in Chongqing. The wastewater treatment fee in the two cities is about the same and the price difference is mainly from the water supply price. The most recent water tariff increase in Shanghai was from 1.84 RMB Yuan per cubic meter in June of 2009 to currently 2.3 RMB Yuan. Before that, water tariffs have been kept at this low level for seven years despite of significant price increases in electricity and gas during the same period. Right on cue, causally or not, annual per-capita water use in Shanghai more than doubles that in Chongqing (see Table 12).

3) Why do prices vary?

According to normal principles of economic pricing and also the general guidance set by the NDRC, the two most important factors that shape water tariffs are water availability and people's affordability. Therefore, lower prices should be expected in cities with high per-capita income (and thus high ability to pay) and scarce water resources (and thus need to signal scarcity with high prices) while higher prices are observed in the opposite circumstances. However, what has been observed in Shanghai and Chongqing (lower water prices in wealthy but water-stressed Shanghai and higher prices in poor but water-rich Chongqing) is conflicted with the general principle. What has been disclosed by this case is that although scarcity and affordability are generally and theoretically important factors that shape water tariffs political organization and local governments' financial strength are more practically critical in determining urban water pricing in China.

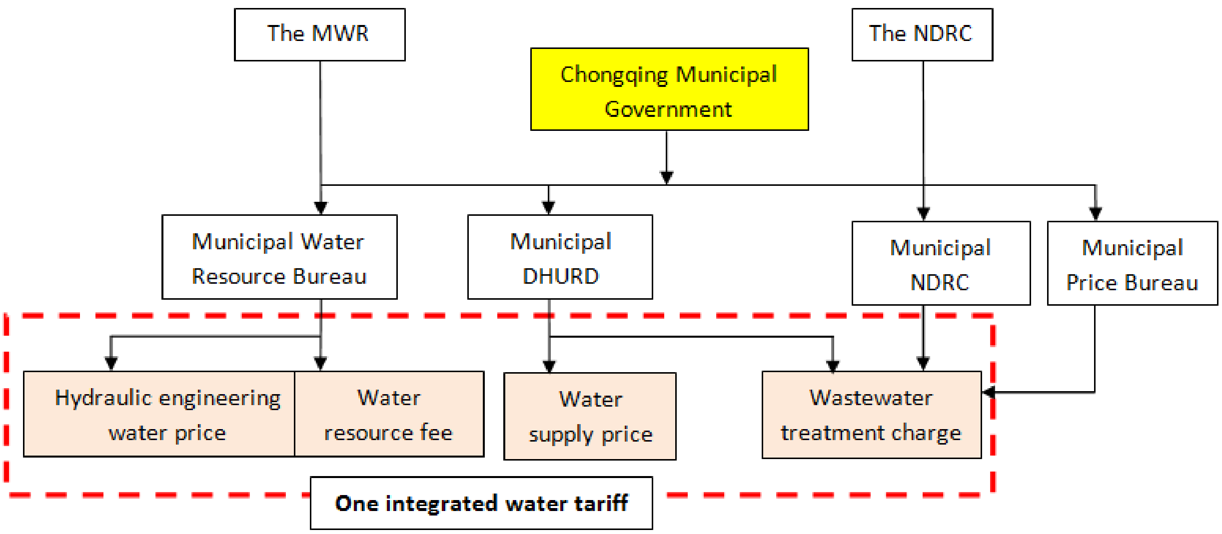
Political organization

Water pricing governance structure differs between Shanghai and Chongqing. Water tariffs are both set and supervised by the two municipal governments. The Municipal Price Bureau holds public hearings for any proposed water pricing change and the municipal NDRC guides local water prices and reports any adjustment to the national NDRC. What differs in the two cities is that just as most Chinese cities, Chongqing has a mode of "water governing by multiple dragons" and water tariffs are set by both the Municipal Water Resource Bureau (the MWRU) and the Municipal DHURD, while Shanghai has a super water bureau called

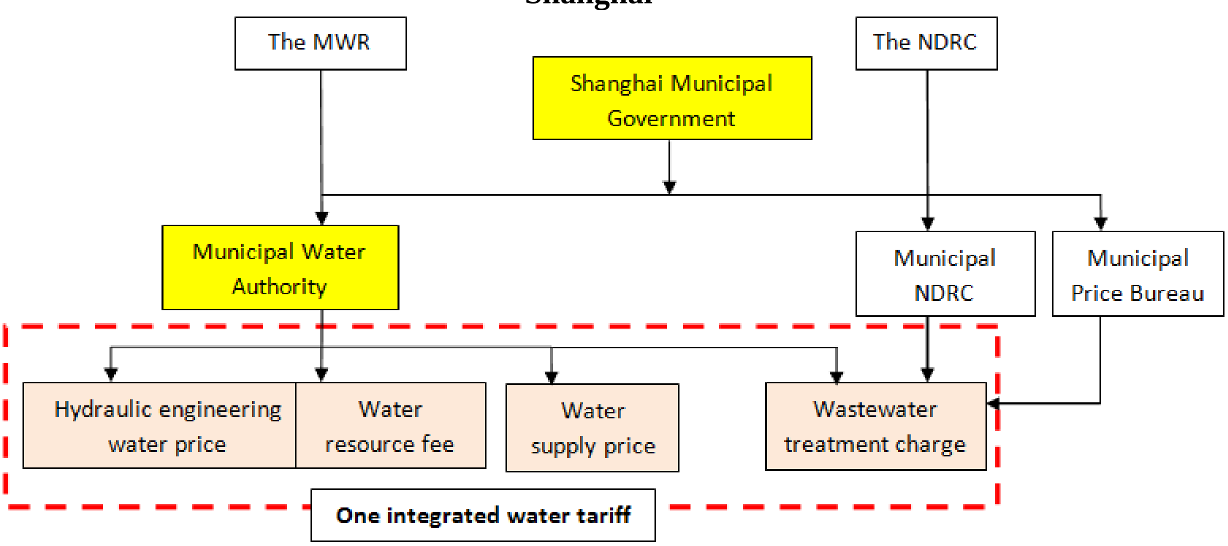
"Shanghai Water Authority" which was newly founded in 2009 and governs all water related issues including water pricing (see Figure 14). This is called the change from "water governing by multiple dragons" to "water governing by one dragon," which aims to address the problem of fragmented water management and marks as the reform direction of the water sector in China.

Figure 14: Major decision players for urban water pricing in Chongqing and Shanghai

Chongqing



Shanghai



<u>Local governments' financial strength: ability to subsidize and invest</u>

To a large degree, the difference in water tariffs between Shanghai and Chongqing leads to the difference in the financial performance of the two cities' water supply enterprises (see Table 13). In China, largely due to low water prices, the financial performance of most water supply enterprise does not look bright. Although the situation is improving due to recent water price increases, there were still 730 water supply enterprises in 2009, about 40 percent of the total, which reported negative net incomes with a total loss of 4.5 billion RMB Yuan. In Shanghai, 9 out of 25 water supply enterprises reported negative net incomes with a total loss of 303 million RMB Yuan. Of all 25 enterprises, the average return on asset (ROA) is about negative six percent with a total net loss of 185 million RMB Yuan. By contrast, 13 out of 25 water supply enterprises in Chongqing reported a total loss of 30 million RMB Yuan and the average ROA of all 40 enterprises is as high as 11.8 percent.

Table 13: Comparison of financial data of water supply enterprises in Shanghai and Chongqing, January 2009 to November 2009

	# of total enterprises	# of enterprises with financial losses	Equity (billion RMB)	Revenue (billion RMB)	Profit (billion RMB)	**Return on asset (%)**
Shanghai	25	9 (36.0%)	26.1	3.4	-1.85	**-6.0%**
Chongqing	40	13 (32.5%)	7.0	1.5	1.46	**11.8%**
National	1,731	730 (42.2%)	387.8	68.3	-3.56	**-0.4%**

Data source: NDRC (2010)

Although there have been emerged more private-owned or even foreign-owned water supply enterprises in China during the water sector reform in past years, the market is still dominated by state-owned enterprises, approximately 60 percent in numbers and 66 percent in equities. The financial performance in stated-owned enterprises is normally worse than those private or foreign-owned and about 80 percent of financial losses in 2009 were reported by state-owned enterprises (NDRC, 2010). These losses are heavily subsidized by municipal governments. In another word, although direct subsidy data is not available, the financial data on water supply enterprises states that Shanghai municipal government has provided much more subsidies to the water supply sector than Chongqing, which to a large degree make its low water tariffs possible.

Besides much more subsidies on water supply enterprises, Shanghai government has provided or attracted much more investments on its infrastructure of water supply and wastewater treatment than Chongqing does, particularly on the water supply sector (see Table 14). In 2008, for example, fixed asset investments on the urban water supply sector in Shanghai is significantly higher than the national average and more than ten times of that in Chongqing.

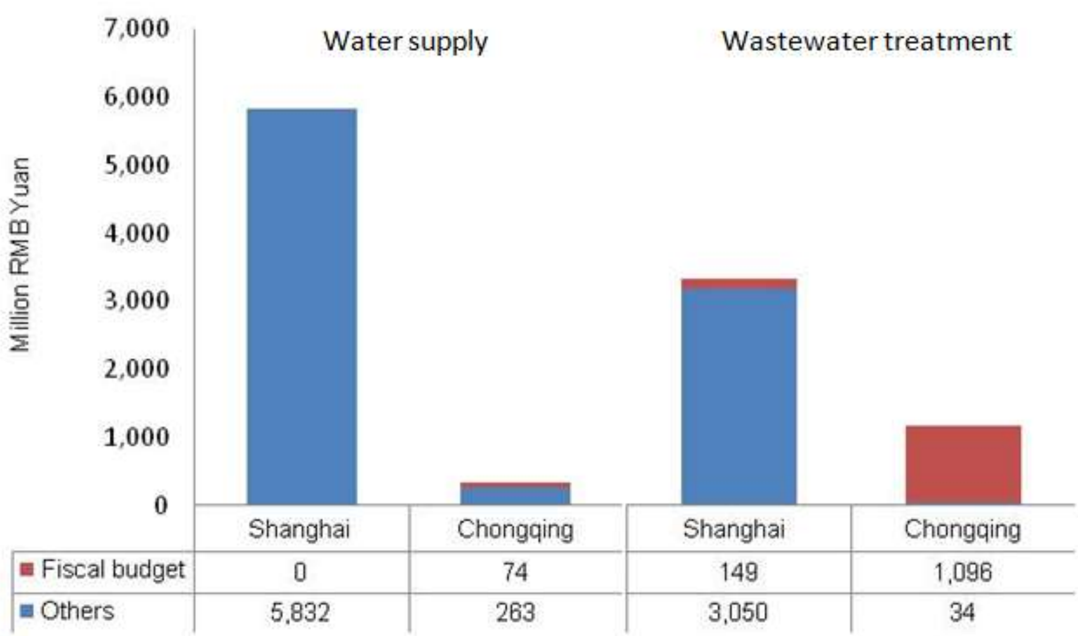
Table 14: Comparison of per-capita fixed asset investments on the urban water sector in Shanghai and Chongqing in 2007 and 2008 (RMB Yuan)

	2008			2007		
	water supply	wastewater treatment	total	water supply	wastewater treatment	total
Shanghai	309	169	478	61	134	194
Chongqing	22	74	96	15	107	121
National average	46	77	123	36	63	99

Data source: MHURD (2009) and MHURD (2008)

The relatively larger investments on the water sector in Shanghai benefits from its mature and open market and multiple financing channels available. It was reported that in 2008 only a small part of investment funding on Shanghai's urban water sector is from its government fiscal budget, although the government has heavily subsidized its water supply enterprises, while in Chongqing a significant share of funding, especially the funding for the wastewater treatment sector, is from the government fiscal budget (see Figure 15).

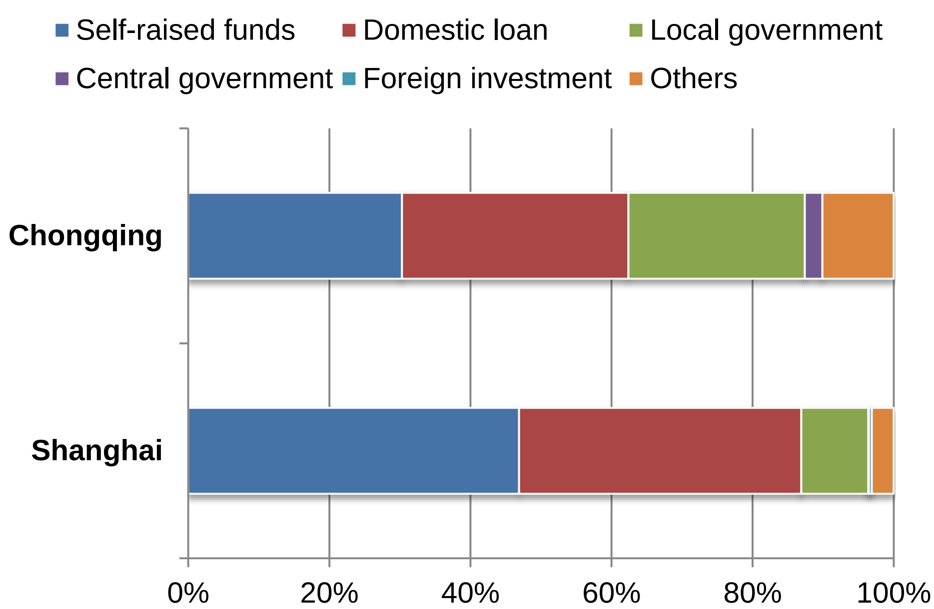
Figure 15: Fixed asset investments on the urban water sector in Shanghai and Chongqing by capital source, 2008



Data source: MHURD (2009)

The share of fixed asset investments in urban service facilities from the central government has been continuously decreasing, for example, from 42 percent in 1980, six percent in 1990, to less than one percent in 2008 (MHURD, 2009). This also applies to the urban water sector although the detailed data is not available. Municipal governments, therefore, have to rely more on either their local fiscal budgets or other capital sources to financing the water supply and wastewater treatment infrastructure, whose growth has long lagged the demand growth. Figure 16 detailed the capital structure of fixed asset investment in the general urban service facilities (including water, gas, public transportation, flood control, landscaping, environmental sanitation, etc.). It shows that Shanghai has been less depended on fiscal budgets (both the central and the local government), but more on other financing channels such as self-raised funds and loans to fund its urban service facilities.

Figure 16: Share of fixed asset investment in urban service facilities in Shanghai and Chongqing by capital source, 2008



Data source: MHURD (2009)

In sum, Shanghai has much fewer water resources and significantly higher disposable per-capita income, but lower water tariffs than Chongqing does. In China, water tariffs are set by municipal governments. Shanghai and Chongqing municipal governments show different governance ideology toward water pricing. Compared to Chongqing, Shanghai consolidates its multiple water-related agencies into one super power water authority, subsidizes more on its water supply enterprises, and invests more with more diversified financing channels on its infrastructure of water supply and wastewater treatment.

6. Summary and conclusion

This case study looks at one of the most visible policy instruments that some Chinese provinces and cities have adopted in an effort to manage water scarcity: raising the price of water. Across China, pricing has evolved from a regime where water was almost free to one, today, where in most urban cities prices are high enough to cover, at least, the operation and maintenance costs of most water supply utilities. In the last two years alone many cities significantly have sharply increased their water tariffs. This case explores three issues.

First, while the NDRC in Beijing continues to provide general guidance on water pricing through its subordinate local NDRCs, but local authorities have large discretion in how water prices are set and reflect scarcity of the resource and social affordability. Municipal water resource bureaus set the price for bulk water supply and depletion of the resource; municipal urban construction agencies set retail water supply prices and wastewater treatment charges; municipal price bureaus manage the process of adjusting water prices. This large discretion for local authorities help explain why water prices, more than most other natural resources, vary so widely around the country.

Second, while many factors interact to shape water tariffs, some of the general patterns are very difficult to explain according to normal principles of economic pricing. Some of the lowest prices are observed in cities with high per-capita income (and thus high ability to pay) and scarce water resources (and thus need to signal scarcity with high prices) while higher prices are observed in the opposite circumstances.

Third, the case study focuses on a comparison of Shanghai (low water tariffs) and Chongqing (high tariffs). These two cities reveal that the form of political organization and local government's financial strengths have a big impact on pricing. Shanghai has consolidated its multiple water-related agencies into one integrated water authority, changing from the old model of "water governing by multiple dragons" to "water governing by one dragon." Wealthy Shanghai invests more with more diversified financing channels on its infrastructure of water supply and wastewater treatment and is more likely to subsidize is state-owned water supply enterprises, which leads to highly inefficient use of scarce resources. By contrast, Chongqing's many dragons each need their own income stream and the lack of coordination between these dragons likely leads to lower investment on its water infrastructure and lower willingness to subsidize state enterprises, which thus, collectively, lead to higher water prices.

VI. Case study: private sector participation in China's urban water sector

1. Introduction

It has become increasingly popular in China to seek private sector participation in the urban water sector. In order to bring in much needed investment and improve service coverage, quality, efficiency, and transparency, China has applied different models of private sector involvement in water supply and wastewater projects, including joint venture, greenfield, commercialization of governmental enterprises/utilities, concession contract, etc. (Zhong et al., 2008).

However, private sector participation in the water sector is one of the most controversial topics in public utility management today and there are growing evidence of failures and increasing public pressure against it (Beecher, 1997; Parker, 1999; Hall, et al., 2005 and Prasad, 2006). Therefore, the purpose of this case is to examine the actual experience in China with private ownership in the urban water sector and its implications on potential governance challenges. This chapter is organized as follows. Section two reviews developments in private sector involvement in China's urban water sector and purposes why China is seeking private. Section three and four analyzes two experiences with private ownership, Shenyang water supply plant's failure on fixed rates of return and Lanzhou water supply plant's controversial high premium. The final section concludes the findings.

2. Overview of the reform of China's urban water sector

1) History and current status

China has made remarkable progress in expanding its urban water supply and wastewater treatment infrastructure and capacity. Over the past 30 years, China has invested approximately 665 billion RMB Yuan in water and wastewater infrastructures. The numbers in 2008 alone reached over 79.1 billion RMB Yuan, which accounted for 0.25 percent of the country's GDP in the same year. The share of the urban population served by municipal water supply utilities increased from 50 percent in 1990 to 95 percent by 2008. Over the same period, wastewater treatment capacity has tripled. As of 2008, municipal plants had the capacity to treat 70 percent of the wastewater generated in urban areas, up from 10 percent by 1990 (China Urban Water Associations, 2009).

Over the same period, China has also experienced its market-oriented reform in the water supply industry. The reform emphasizes the importance of the market, investment and financial liberalization, deregulation, decentralization, and a reduced role of the state in the water sector (Prasad 2006; Zhang et al., 2008). Many multinational water corporations, for example, have become involved in China's urban water sector by establishing national and regional offices and starting negotiations with some of the more developed cities over water supply and treatment projects. Sino French Water (a joint venture between France-based Suez Group and Hong Kong-based NWS Holdings Limited) was the first to participate in China's urban water supply sector and signed in 1992 a 35-year water supply contract with the City of Zhongshan, Guangdong Province.

Since then, several international water companies including the two French water giants, Veolia and Suez, have been actively engaged in China's gradually opening urban water market. Veolia Water is currently operating in 20 out of 34 provinces, municipalities, autonomous regions and special administrative regions in China and providing water service to over 30 million urban residents (Veolia Water China, 2010). Sino French Water has 22 joint ventures in 16 Chinese municipalities and serves more than 14 million people (Sino French Water, 2010).

It is reported that, however, state-owned water supply enterprises still hold the majority share of the market, approximately two-thirds of the total equity in 2009. The share of foreign-owned is about 10 percent and domestic private-owned or public-owned companies control for the remaining 20 percent (NDRC, 2010). Beijing Capital Co., Ltd, for example, is one of the largest state-owned water companies in China, which is capable to treat over 7.6 million tons of water and serve a fixed urban population of over 14 million (Beijing Capital Co, 2010). In many other cases, local city-based water companies, which were transformed from municipal government departments to state-owned companies, are still dominant in many parts of the country, as a result of support from municipal governments.

2) Regulatory environment

The Chinese government has been gradually building up a legal framework to help reform its urban water sector, although largely as a reactive process, where various policy papers address specific problems arisen in the reform process. In the mid 1990s, the central government attempted to introduce the Build-Operate-Transfer (BOT) approach into the field of urban infrastructures via promulgating two policy papers, *Circular on Attracting Foreign Investment through BOT Approach* and *Circular on Major Issues of Approval Administration of the Franchise Pilot Projects with Foreign Investment*. These two papers formed the first legal ground for private sector involvement and foreign capital investment in Chinese urban infrastructure.

To address the issue of foreign investment projects with fixed investment returns (to be discussed in details in the next section), a specific circular was issued in 2002 and declared that guaranteed rates of returns were illegal for private utility contracts. The circular corrected the issue by modifying the relevant contract terms, buying back all shares of foreign investors, transferring foreign investment into foreign loans, or dismantling contracts with often severe losses.

The full-fledged commitment of the Chinese government to private involvement in the water and other utility sectors dates from late 2002. *Opinions on Accelerating the Marketization of Public Utilities* was issued December of 2002 and raised for the first time the concept of government franchise and opened public utilities to both foreign and domestic investors. The subsequent *Management Measures for Concession of Public Utilities* was issued in 2004 and further specified procedures of how to involve the private sectors in public utilities through awarding concession rights.

3) Reform purpose

China's urban water sector has been long suffering from investment shortages and inefficient services. The growth in Chinese urban population, combined with aspirations to improve the quality of water services, requires an accelerated investment need in the sector. It is estimated that China is going to invest more than a trillion RMB in urban water service in the next five to ten years: approximately 270 billion RMB for protection of water sources and security of water supply, 330 billion RMB for wastewater treatment and water reuse, 250 billion RMB for constructing of long-distance water transfer facilities, and 150 billion RMB for repairing and restoring of the water environment (Zhang and Zheng, 2008). It is a major challenge to finance these investments and ensure investment efficiency.

The picture does not look bright yet on the financial performance of Chinese water utilities, although the situation is improving due to recent water price increases. About 42 percent of water supply utilities in China reported negative net incomes in 2009 (NDRC, 2010) and the financial state of wastewater entities is certainly more precarious than that of water supply utilities, although there is no comprehensive data for the wastewater sector. The service quality of China's water supply utilities is variable. It is estimated that one-quarter of the water utilities are unable to provide adequate water pressure to more than 40 percent of their service area. On average, about 20 percent of the water produced at the water treatment plant is lost through leaky distribution pipes. The leakage rate calculated in terms of water loss per kilometer of pipeline is exceptionally high in China compared to international standards (World Bank, 2007b).

It was believed that private sector participation in the water sector would bring in much needed investment and improve service coverage, quality, efficiency, and transparency by replacing conventional public-sector systems suffering from under-investment and inefficiencies (Hall and Lobina, 2005; World Bank, 2007b). However, although it would be too early to make a conclusion on the private sector participation, problems or challenges do emerge during the process, such as unequal power relations and information asymmetry in public-private partnerships, government accountability, access for the poor, and participation and democracy in decision-making.

3. The case of Shenyang water supply plant: problems of fixed rates of return

Shenyang, capital of Liaoning Province, is the largest city in the northeastern China. Suffering from fiscal deficits in its urban water supply sector, the city began its market-oriented reform on the sector in 1995 when it signed a joint-venture contract with Sino-French Water Development Company for selling a half of its No 8 water plant assets. Since then, the urban water supply sector in Shenyang has experienced various models of marketization reform including joint venture, BOT, and overseas IPO, which could well shed insights on potential problems and governance challenges during the reform process.

The urban water supply reform in Shenyang has experienced trial and error and finally returns to the wholly state-owned company. Since 2008, newly established state-owned Shenyang Water Group has been controlling the operation of the whole water system within Shenyang. This water reform in Shenyang is an asset-driven or finance-driven practice. It is a typical one occurred in the early stage of China's urban water sector with guaranteed fixed rate of foreign investment returns, higher water prices than what water users actually pay, or guaranteed water purchase amount. The foreign partner was often subjectively chosen in a short course without open bidding and the Chinese side was often at disadvantage side without professional financial consultants or lawyers. The decision is most likely the result of a closed discussion by core officials, or even manipulated by corrupted local official. This water reform in Shenyang in 1990s and early 2000s were somewhat related to political scandal. The municipal government lost tremendously in these public private partnerships, but there is no one or single agency that can account for the huge loss.

1) No. 8 water plant joint venture

In 1995, the stated-owed Shenyang Tap Water Company built the No. 8 Water Supply Plant with a loan of 250 million RMB Yuan from the World Bank. The plant had a daily water supply capacity of 400 thousand tons and used high-quality surface water from the Dahufang reservoir. In order to help finance the construction of its urban infrastructure, the Shenyang municipal government signed a joint venture contract with Sino-French Water Development Company, a partnership between France-based Suez Environment and Hong Kong-based NWS Holdings Limited, and sold half of the plant's fiscal assets to the company, a value of total 125 million RMB Yuan.

According to the agreed 30-year contract, Sino-French would not receive any return on investment for the first pilot year, but a guaranteed 12 percent during the second and third years, 15 percent during the fourth and fifth years, no less than 18 percent from the sixth year to the 12th year, and 18 percent from the 13th to the 30th year. The average fixed rate of return was no less than 18 percent. The contract was signed in April of 1995 and the joint venture began operating in early 1996. During the contract negotiation process, the Shenyang municipal government did not hire any financial consultants or lawyers, while Sino-French had the world-leading professionals. The contracted was drafted by Sino-French, although signed by both sides.

In 1999, the Shenyang municipal government founded Shenyang Development Ltd, Co. and attempted to make it public in the overseas market to finance its utility infrastructure. The government wanted to put all assets of the No. 8 Water Supply Plant under Shenyang Development Ltd, Co. and therefore, terminated the joint venture contract and purchased back Sino-French's entire stake for 150 billion RMB Yuan. Within three years, Sino-French not only received fixed-rates investment returns and an investment premium of 25 million RMB Yuan from the joint-venture contract, but got a 10-year contract for providing technical supports for all eight water supply plants in Shenyang, a value of total 50 million RMB Yuan (Xu and Qing, 2006; Fu et al., 2008).

2) No. 9 water plant BOT:

In 1996, Shenyang Tap Water Company joint ventured with Hongkong Huijin China Company to develop No. 9 water plant with a daily water supply capacity of 100 thousand tons. In the joint venture, Hongkong Huijin China Company invested USD 25 million, while Shenyang Tap Water Company was in charge of construction and operation of the water plant. It was a 20-year BOT project and the plant would be transferred back to the government by the end of the 20 years.

The Chinese side promised a high fixed rate of return to the Hong Kong Company, which in the contract specifying 18.5 percent from the second to the fourth year, 21 percent from the fifth to the 14th year, and 11 percent from 15th to the 20th year. The Chinese side also promised a high fixed water price and a high fixed annual water purchase amount. The average water price in Shenyang was 1.5 RMB Yuan per cubic meters in 1996, while Shenyang Tap Water Company paid the joint venture 2.5 RMB Yuan. Until 2000, it was estimated that Shenyang Tap Water Company lost about RMB 200 million in this deal. By contrast, Huijin was able to successfully cover all its investment within five years.

Per the special circular 2002 on management on foreign investment projects with fixed investment returns, the Shenyang municipal government repurchased 50 percent of stakes from Huijin, about USD 12.5 million, and reduced the annual fixed rate of return from 17.325 percent to 13.3 percent by the end of 2001 and the re-joint venture contract was set to start from early 2001. Meanwhile, both sides agreed that the foreign side would sell the remaining half equity to Shanyang Tap Water Company when conditions permitted (Fu et al., 2008; Qing, 2010).

4. The case of Lanzhou water supply plant: controversy of high premium

There is a considerable controversy on the “high premium” that French company Veolia paid in 2007 to acquire 45 percent equity of Lanzhou Water Group Company. The public complain that the takeover caused the city’s water price hikes and the government should not sell the state-owned enterprise which provides public goods.

Lanzhou, the capital city of Gansu Province, is located in northwest China and on the upper reaches of the Yellow River with ample capacity of hydroelectricity generation. As many other peers in China, the state-owned Lanzhou Water Group established in 1955 was burdened with loans of 1.1 billion RMB, a debt of 619 million RMB, monthly losses of more than 1000 million RMB, obsolete facilities, and inefficient services (Li, 2007).

Early in 2006, the Lanzhou municipal government decided to sell part of the stake in Lanzhou Water Group. In the opening tender late that year, Veolia bid 1.71 billion RMB ($248 million) for 45 percent of Lanzhou Water Group and the wastewater treatment project, the total net asset value of which was about 490 million RMB. The bid was almost four times of the net asset value transferred and far ahead of Sino-French Water's bid 450 million RMB and Beijing Capital Group's bid 280 million RMB.

Unlike the asset transfers occurred in Shenyang, the Lanzhou municipal government hired professional institutions, well prepared it for a whole year, issued a formal transferring announcement well ahead of the worldwide tender, and held a grand ceremony for the opening of tenders. In the 30-year contract there is neither guaranteed fixed rates of foreign investment return nor guaranteed paid water price, although the municipal government orally promised an annual increase of RMB 0.2 per cubic meter.

Veolia explained that the high premium was paid for an anticipated future growth of China's water sector and the company was much more optimistic for the Chinese market than other competitors. The Lanzhou municipal government argued that compared to other state-owned water enterprises Lanzhou Water Group Company was in a much better shape on after it accomplished the decade-reform of state-owned enterprises and therefore, the premium paid by Veolia is not unreasonable. However, a majority of outsiders put a big question mark on the high premium. Chief executed officer (CEO) of Suez Environment, for example, acclaimed the price Veolia paid was impractical and unreasonable. Observers believed Veolia would only get back its huge investment only if it significantly raised the water price. A water expert in Tsinghua University wrote in his blog that there is no free lunch and every sum of money bears the cost of corresponding needs and will call back later (Fu, 2008).

Right on cue, causally or not, there is a new round of price hikes since early 2009, which has sparked a nationwide debate and provoked public opposition. There were two water price increases in Lanzhou since the takeover, one from RMB 1.8 to RMB 2.0 in September 2008 and the other from RMB 2 to RMB 2.25 in November 2009. Although Lanzhou is neither the first city with a water price increase nor the one with the highest increase, this controversy focuses on whether the "high premium" foreign takeover causes water price increases.

Both the new joint venture Lanzhou-Veolia Water Co. and the provincial NDRC explained that the long-due increase was due to cost recovery. But public hearings are full of questions about the truth of these claims. For example, the company which answered questions in the public hearing did not disclose the composition of certain costs, including management, entertainment, and other categories accounting for more than 30 percent of the company's expenses. Significant increases in staff salaries and over-hiring at water supply companies also deserve closer inspection.

However, Lanzhou is not the only city in China where foreign companies paid high premium in order to secure more markets in China's urban water sector. Veolia, for example, paid 2 billion RMB for a half of the stake of Shanghai Tap Water Company in 2002. It was the first high-premium purchase case in China's urban water sector and the bid was three times of the net asset value of what they got. In August of 2007, Sino-French Water Development Company purchased 49 percent of the stake of Yangzhou Tap Water Company in Yangzhou, Jiangsu Province, a total asset value of 180 million RMB. Sino-French paid 895 million RMB, a price well ahead of the other three bidders' (Du, 2007). But up till today, except for Lanzhou, all these high premium cases happened in first-tier or rich coastal cities in China.

Despite of five increases within nine years, water prices in Lanzhou is still below the national average. The Lanzhou Water Spending Coefficient (the ratio of household water expenditure to per capita disposable income) was approximately 0.68 percent in 2008 (Liu, 2009) and was still close to 0.7 percent after the increase at the end of 2009. According to international research, residents generally pay and accept a ratio of up to one percent. As the coefficient rises to between two and 2.5 percent, residents begin to pay considerable attention to water conservation (Liu, 2009). From this perspective, Lanzhou water prices have room to rise.

5. Summary and conclusion

In most areas of infrastructure China relies on state ownership, but in water it has become increasingly popular to seek private sector participation in the urban water sector. This case study examines three aspects of private ownership in China.

First, reform of the water sector began in the 1990s in the context of broader economic reforms in China aimed at encouraging more private (even foreign) investment. These reforms were motivated by the huge need for investment and concern that the traditional state-centered model would lead to inadequate investment and also economically inefficient operations.

Second, while it is still hard to make firm conclusions about the actual experience with private ownership, the initial experience suggests that many of the problems that have appeared in the rest of the world are also serious problems in China. Those include poor public participation in decision making; large asymmetries in power and information between public institutions and private investors; and governance gaps or failures in the selection of private partners, contract provisions, cost information disclosure, and assurance of service quality. For private investors perhaps the largest challenge is the one that has undercut many privately owned water infrastructure around the world: unpredictable government decision-making about contract terms and tariffs leading private investors to fear expropriation of their investment.

Third, this study looks closely at two experiences with private ownership: Shenyang and Lanzhou. The case of Shenyang reflects that large information asymmetries and governance failures in the selection of private partners and contract provisions could lead to adverse effects on the local community. Driven by both infrastructure financing needs and local officials' needs for political promotion, the Shenyang government is keen to attract new investment and foreign sources that are relatively easy to tap. In this case local officials developed a joint-venture to build a utility with foreign capital and expertise, but government chose its foreign partner without thoughtful planning and open bidding and rushed into an unequal contract with guaranteed fixed rate of return. Unable to achieve that rate because it proved politically difficult to raise water tariffs and facing continued losses, the government forced termination of the contract and repurchased the assets at huge cost. This outcome was typical of many water infrastructure privatizations, and in 2002 the central government issued a specific circular which banned fixed rates of return for private utility contracts. Foreign investors soon lost interest in the sector.

The case of Lanzhou reflects that in the context of the increasing private sector participation and the reducing government role in the urban water sector, it is vital to ensure equitable prices and high-quality service with supplemented governance mechanisms such as transparent information disclosure, improved public participation, and well defined and enforced legal instruments. Private ownership of infrastructures requires a government that is highly capable of obtaining information and managing contracts. In this city, as in many others around the world where foreign investments required hard budget constraints and thus higher tariffs to make the books balance, there was strong public opposition to higher tariffs and complaints about failure to yield expected improvements in water quality after private or foreign-owned companies purchase public assets with a high premium. With the development of private sector participation in the urban water sector, the traditional structure of full governmental provision of water supply and wastewater treatment has changed dramatically and therefore, the traditional government governance in the sector is also changing. It would be too early now to draw any final conclusion on the impact of private sector participation in China's urban water sector due to the early stage that most contracts are still in. However, from current case projects we can see the governance gaps in the sector, which are not only reflected in the market entry process, award criteria, contract provisions for the unforeseen contingencies and information asymmetry, and local official's accountability for contracts and projects, but also in how to price water efficiently, equitably, and transparently and how to guarantee the access of high quality water services to all people during the execution of those contracts.

VII. Case study: China's South-to-North Water Diversion Project

1. Introduction

In order to address severe water scarcity in China's North China Plain (NCP), China has officially launched the South-to-North Water Diversion Project in December 2002 after a 50-year long period of feasibility study. It is a well-known controversial high capex water infrastructure project due to its high risk and high cost (World Bank, 2001; WWF, 2001; Berkoff, 2003). While this project is usually viewed through the lens of the engineering challenges, the purpose of this case study is to look into the governance challenges--including how to build the institutional capacity to finance and operate the infrastructure and the provisions that have been made to ensure the project improves public welfare—especially of the populations that are being resettled due to the project.

This chapter is organized as follows. Section two reviews the magnitude of waster deficits in the North China and the drivers of the central decision to launch the mega project. Section three presents in details the project's three proposed transfer routes including their construction designs, current status, and specific route challenges. The focus of the case study then turns to in section four the governance challenges that the project faces. The final section concludes the findings.

2. Water stress in the North China or 3-H Plain

The NCP is served by three major rivers (the Hai, Yellow (Huang), and Huai River), so also called 3-H Plain. The area is subjected to severe water scarcity. Compared to the world average of 8,210 and the national average of 2,071 cubic meters, per-capita freshwater availability is merely 343, 706, and 487 cubic meters in the Hai, Yellow, and Huai plain, respectively (Shao and Wang, 2003). The NCP contains about one-third of China's population, produces one-third of its GDP, and cultivates two-fifths of its farmland. This is supported, however, by less than 8 percent of the nation's water.

Numerous studies have projected the huge gap between water supply and demand in the North China (IWHR, 1998; World Bank, 2001; Pan and Zhang, 2001; Liu and Zheng, 2002). Table 15 is taken from the Pan and Zhang (2001)'s study, which was jointly conducted by the Chinese Academy of Engineering and the Chinese Academy of Sciences. This study has been considered the most authoritative in China and has provided an important basis for the final decision on the project (Yang and Zehnder, 2005).

- Industrial and domestic water demands are forecasted to rise in the 3-H basins from 50.5 billion cubic meters in 2010 to 65 billion by 2030.
- Agricultural water demand almost remains the same level in the 3-H basins, but will easily stay the largest single use, accounting for approximately 30 percent of the total.
- There will be water deficits in all three basins by 2030. The most acute one is seen in the Hai basin, where the water gap is as wide as one quarter of the total demand.

Table 15: Projections for water demand and supply in 2030 for the 3-H basins (billion m3)

Basin	Demand					Supply	Deficit	
	Industry	Domestic	Agriculture	Ecosystem	Total		Amount	%
Hai	10.0	8.4	32.9	2.6	53.9	40.5	13.4	25%
Huai	16.8	12.4	53.7	1.4	84.3	81.3	3.0	4%
Huang	11.0	6.4	35.2	2.5	55.1	46.3	8.8	16%
Total	**37.8**	**27.2**	**121.8**	**6.5**	**193.3**	**168.1**	**25.2**	**13%**

Source: adapted from Pan and Zhang (2001)

The projected large and widening gap between water supply and demand suggests that the North China Plain is facing a severe and worsening water deficit. A solution is not only urgently needed to alleviate water stress in the economic sectors but to recover the ecosystem on the North China Plain as well. In the Hai basin, for example, the picture has been painted as "wherever there is a river, it is dry; wherever there is water, it is polluted" (Zheng, 1999).

Although the proposed South-to-North Water Diversion Project (SNWTP) is quite a controversial solution to the problem, but given the magnitude of deficits at present and in the coming years, none of the alternatives to the SNWTP is likely to provide a satisfactory solution (Berkoff, 2003). Improved efficiency, for example, has an important role to play but its contribution is likely to be far less than enough to radically solve the problem. Reallocating water from irrigation to the domestic and industry sectors is, in principle, attractive but raises formidable socio-political issues and is not always technically feasible. Desalination is a possibility for some priority water uses in coastal cities, but cannot practically serve general water use for all three basins.

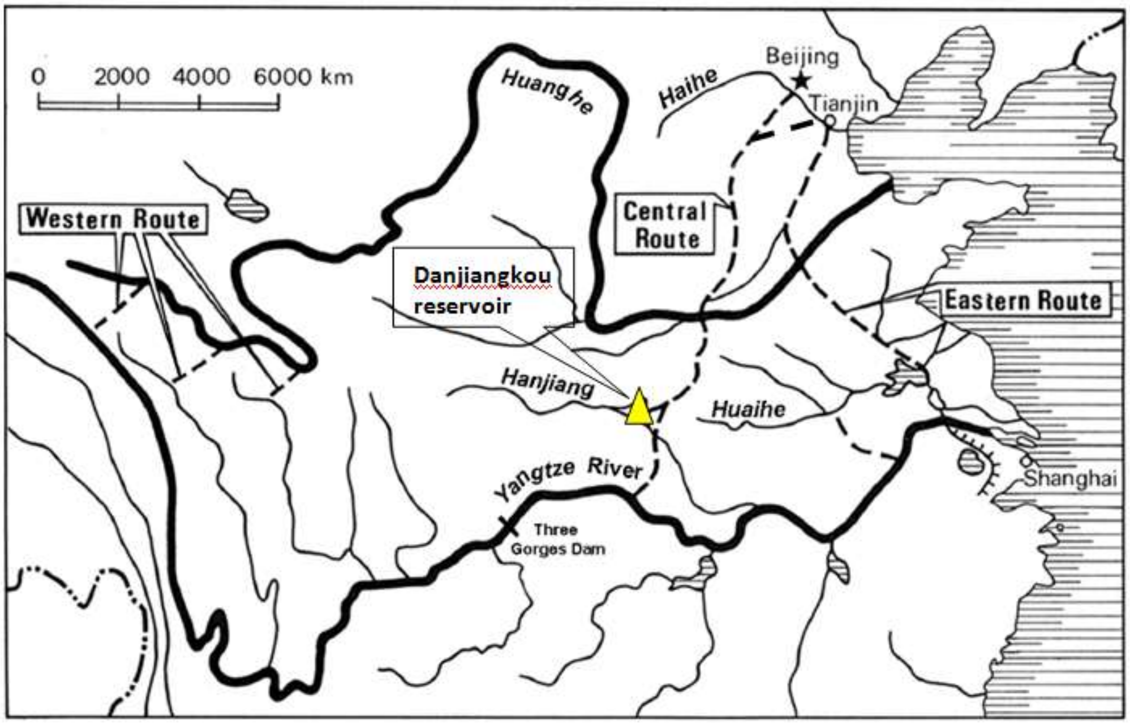
Therefore, it is believe that the conclusion has been the need for the SNWTP which is not only based on economic or food security concerns, but more likely on political concerns (Berkoff, 2003). The project is considered necessary to enhance the image of the North China Plain in general and Beijing in particular (Wang, 2001).

3. Overview of the South-to-North Water Diversion Project

The SNWTP was first proposed by Chairman Mao Zedong in the early 1950s, who said "the south has a lot of water, while the north has little. If possible, it is ok for the North to lend a little water from the South (Yang and Zehnder, 2005)." After a 50-year long period of feasibility study on the project, carried out mainly by the MWR and the Yellow River Commission (YRC), China formerly launched the mega-project in December 2002 and set up the SNWTP Construction Committee directly under the State Council in August 2003.

It is the largest of its kind ever implemented worldwide with three proposed routes (i.e., the Eastern, Central or Middle, and Western Route). The three routes will each serving separate areas, with the exception of the coastal city of Tianjin, which will receive water from both the Eastern and Middle routes. The Eastern and Middle routes will pass under the Yellow River, while the Western route will directly replenish the Yellow (see Figure 17).

Figure 17: Sketch Map for Three Routes of China's SNWTP



Source: adapted from Yang and Zehnder (2005)

The Eastern Route expands an existing diversion beginning near city of Yangzhou in Jiangsu Province using the existing Grand Canal and some parallel riverbeds. The water will be lifted 65 meter by 13 pump stations to the Yellow River, crossed by tunnel. From there, water can flow north by gravity across the Hai basin to Tianjin, using five expanded or newly created regulating reservoirs. The trunk canal will be about 1,156 km long, 660 km of which is south of the Yellow. Branch channels will have a total length of about 740 km. Only about 12 percent of the total length will require entirely new channels, while an additional nearly 40 percent will require some enlargement of capacity.

The construction of the Eastern Route was formally launched in December 2002. Water is originally expected to begin flowing in 2007 and the first phase was accomplished by 2010, then to be followed by a second stage in the following decade (2010-2020). However, in 2008, two years before the scheduled water flow date, the SNWTP Construction Commission officially announced the delay and the first phase was scheduled for completion in 2013.

The Middle Route takes water from the Danjiangkou Reservoir on the Han River, a tributary of the Yangzi River, in Hubei Province and diverts it through Hubei, Henan, and Hebei Province before reaching Beijing and Tianjin. In addition to the canal, which unlike much of the Eastern Route must be newly dug, a key component of the project is the heightening of the Danjiangkou dam by 15 meters. The central trunk canal of the Middle Route will be 1,241 km long, plus a 142 km branch canal to supply Tianjin.

The construction of the Middle Route was formally launched in 2003. The construction linking four reservoirs in Hebei with Beijing was completed in 2007 and already provided its first emergency supply of water to support the 2008 Beijing Olympics. It was estimated that between September 2008 and July 2009 Heibei transferred a total of 43.5 billion cubic meters of water to Beijing (Zhou and Long, 2010). The heightening work on Danjiangkou began in September 2005 and already accomplished this May. This August the first communities along the Middle Route began their resettlement from Danjiangkou to nearby Shayang County. It's expected that by 2014 about 180,000 people will be relocated within Hubei and 150,000 to Henan (Barclay, 2010). Water is originally set for flowing in 2010, but was also later adjusted to 2014.

The Western Route is located in a remote and the least developed regions of China and cover parts of six arid northwestern provinces and autonomous regions (Qinghai, Gansu, Ningxia, Shaanxi, Inner Mongolia, and Shanxi). The Route has three proposed diversions, all of which are from the upper reaches of the Yangzi River into the upper reaches of the Yellow River. Water is transferred via tunnels (131 km, 158 km and 28.5 km long, respectively) through the earthquake-prone Bayankala Mountains. Unlike the other two routes, more than half of the water from the Western Route would go to the agriculture sector. Many experts say the Western Route would be immensely expensive and difficult, and no launch date for construction has yet been announced.

Overall, by 2050 the three-route project will be capable of transferring a total of 44.8 billion cubic meters of water each year from the water rich Yangtze River to the arid north (see Table 16), almost an equivalent of a second Yellow River.

Table 16: The Comparison among the Three Routes of China's South-to-North Water Diversion Project

	Eastern Route	Middle Route	Western Route
Water transfer capacity (billion m^3)	14.8	13	17
Length of diversion canal (km)	1,156 (main canal) plus 740 (branch line)	1,241 (main canal) plus 142 (branch line)	>300 (all via tunnels)
Dam construction	N/A	Existing dam heightened by 15 m from 162 to 176.6	New dam >200 m in height
Water transfer method	Pumping stations	Flow by gravity	both
Construction schedule	Started in 2002; Water was expected to begin flowing in 2007, but was later delayed to 2013	Started in 2003, water was expected to begin flowing in 2010, but was later delayed to 2014	Under planning
Water flowing areas	Jiangsu, Anhui, Shandong, Heibei, and Tianjin	Hubei, Henan, Hebei, Beijing, and Tianjin	Qinhai, Gansu, Shannxi, Shanxi, Ninxia, and Inner Mongolia
Major challenges	• Poor water quality • Ecological impacts of lake impoundment	• Resettlement • Discharge reduction of the Han River	• Geological disasters • Impacts on the ecosystems of the upper Yellow River

Source: Adapted from Zhang (2009) and Shan (2009)

None of the three routes are free of challenges. For the Eastern Route, one major concern is the water quality degradation along the channel (Liu and Zheng, 2002; Zhang, 2009). The East Route is laid on one of the most developed regions of China. The water quality at the source meets only the minimum requirement for drinking and likely deteriorates steadily northward due to the influx of large amounts of untreated industrial wastewater and of nonpoint pollution from agricultural activities along the route. Although the government has been very active on pollution control in past decades, monitoring results suggest efforts are not very effective (Zhang, 2009). Other major challenges include the ecological impacts on the aquatic ecosystems of lakes due to a reversal of the hydrologic regime, a secondary salinization in the receiving areas including Tianjin and Jiaodao Pennisula, and northward migration of alien species and the proliferation of parasitic diseases such as schistosomiasis (Zhang, 2009).

The construction of the Middle Route will face the same challenges as the Eastern Route does including secondary salinization in the receiving areas and invasion of alien species. Additionally, the other two major concerns are the large displacement of people due to the need to raise the Danjiangkou Dam and discharge reduction in downstream of the Han River. Inundation will also likely displace some 330,000 people (Barclay, 2010). The real number, however, could be much larger (Yang and Zehnder, 2005). Resettlement will not only be costly, but may pose social, economic, and ecological problems in the region and beyond.

The average annual discharge of the Han River is only 48 billion cubic meters, larger than what is consumed at present. However, the diverted water of 14 billion cubic meters each year at the point of transfer (i.e., the Danjiangkou Reservoir) will have significant impacts on the economy and ecosystems in the source area. Without substantial reductions in wastewater discharge into the river, for example, elevated phosphorus and nitrogen levels will lead to increases in the plankton bloom in the spring (Zhang, 2009).

The Western Route goes through the remote Qinghai Plateau and northwestern arid and semi-arid areas. The construction cost is deemed to be very high and more challengingly, the construction of this route may lead to geological disasters (e.g., earthquakes and landslides) and pose significant impacts on the riverine ecosystems of the upper Yellow River (Zhang, 2009). Considering the project's extraordinary cost and risk, many senior Chinese experts including several authoritative ones in hydraulic engineering and water resource management have expressed their reservation and suggest further comprehensive feasibility studies before any construction (Wang, 2009).

4. Challenges of the project: more governance than engineering

Due to the high risk and high cost, the SNWTP has been under the feasibility study for over 50 years and the Western Route is still under plan. The biggest challenges confronting China are probably not engineering, but of institutional capacity to finance and operate the diversions in a way to ensure that water of adequate quality actually makes it to the end of the line, to maintain or even improve the welfare of the resettled people, and meanwhile to ensure no repeat of embezzlement or any political corruption.

1) Financing challenge

The SNWTP is a vast and unprecedented water project in human's history and costs as high as nearly $100 billion covering a period as long as 50 years. Undoubtedly, it would be a huge challenge even for China to financing such a mega project, no matter with regard to both who should pay and how they pay.

Shortly before the SNWTP was approved, the total estimated cost for all three routes, to the end of construction in 2050, was 314 to 354 billion RMB (about $40 billion), using 1995 prices. Construction cost of the Eastern and Middle Routes in the first stage was approximately 18 and 23 billion RMB, respectively (see Table 17).

Table 17: Estimated Cost of the SNWTP (billion RMB Yuan)

	Stage I (2000-2010)			Stage II (2010-2020)		Long-range (2020-2050)	
	old[1]	updated[2]	updated[3]	old[1]	updated	old[1]	updated[2]
Eastern	17.9	35	117.9	11.3	-	-	-
Middle	23.4	99	136.7	31.5	-	-	-
Western	-	-	-	0-20	-	230-250	300
Total	**41.3**	**124**	**254.6**	**42.8-62.8**	**-**	**230-250**	**300**

1. Data is using 1995 price from Qian and Zheng (2001)
2. Data is from MWR (2003) which did not indicate on what year's prices
3. Data is from Li (2009) which did not indicate on what year's prices

Projected costs, however, have dramatically increased due to hikes in commodity prices and the addition of many unforeseen costs, such as for pollution control along the Eastern Route and ecological compensation for the downstream of Han River. The official number for the total budget for the project's first phase announced in 2003 was 124 billion RMB, while a most recent updated figure increased up to 254.6 billion RMB (nearly $40 billion), although both sources did not indicate in what year's prices.

Securing funding for such a massive water transfer project was a major challenge that was further complicated by the fact that water would be transferred among different provinces which all have their own administrative powers and economic interests and the fact that water infrastructure is long considered to be part of the national infrastructure in China and provinces were not keen to finance national infrastructure. China has come up with a co-financing arrangement with funding from three separate sources including the central government, local governments, and banks. A construction fund is established to cover construction, interest and maintenance cost, which is shared by water receiving regions by charging individual users for their water use.

Without details for the updated 254.6 billion RMB budget, of the old 124 billion RMB budget for the project's first phase, 37.3 billion is from the central government's fiscal budget and treasure bonds, 55.8 billion from bank loans, about half of which is from China Development Bank, a policy bank, 31 billion from the SNWTP Fund collected by local governments of water receiving regions including Beijing (5.43 billion), Tianjing (4.38 billion), Heibei (7.61 billion), Jiangsu (3.7 billion), Shandong (7.61 billion), and Heinan (2.6 billion).

Due to the concern on whether the SNWTP Fund can be timely collected from the local governments, the share of central government financing, originally set for 20 percent, was increased up to 30 percent while the share of local governments was reduced from 35 to 25 percent. The fund collection, however, is still far short of the target. As of August 2010, the total amount of funds collected is merely one third of the target (see

Table 18).

Table 18: Budget for the First Phase of the SNWTP (billion RMB Yuan)

	Central government budget	SNWTP Fund	Bank Loan	NKHEC Fund[1]	Total
Budget fund[2]	37.2 (30%)	31 (25%)	55.8 (45%)	-	124
Funds available[3]	33.9 (34%)	9.9 (10%)	31.9 (32%)	24.2 (24%)	100

1. The NKHEC Fund refers to the National Key Hydraulic Engineering Construction Fund
2. MWR (2003)
3. Data is from SNWT Office (2010), as of end of August 2010

This large financing gap is now filled by the National Key Hydraulic Engineering Construction (NKHEC) Fund, which currently accounts for about one quarter of funds available for the project constructions. The NKHEC Fund was initiated as a substitute for the Three Gorges Dam Construction (TGDC) Fund, which was raised by charging a certain levy on every people' electricity bill and officially stopped its collection on January 1, 2010 when the dam project was accomplished.

The successful collection of the SNWTP Fund is largely dependent on if local governments can timely raise and collect water resource fee. The payback to bank loans including both principles and interests also relies on income from water tariffs. However, it would be a big question mark if water prices in those water receiving areas could be timely raised to a level, at which prices could not only cover the construction and maintenance costs of the SNWTP, but the increasing costs of water supply and waste water treatment as well. According to estimates of MWR officials, once water officially flows from the Yangzi River to Beijing and Tianjing, water prices should be at least as high as 7 RMB Yuan per cubic meter to cover all costs (excluding cost of ecological compensation for water exporting regions). The highest water price currently seen in Beijing, however, is merely 4 RMB Yuan per cubic meter. It poses a huge challenge for China's governments to efficiently, equitably, and smoothly raise water prices.

2) Resettlement challenge

Another challenge that Chinese governments have to face is a large scale resettlement. Roughly 450,000 people have to be relocated, among which 330,000 is in the Danjiangkou reservoir for the constructions of the Middle Route (Liao, 2010). This is a resettlement with the similar intensity as the one for the Three Gorges Dam Project. Although Chinese government have learnt lessons from previous resettlements, particularly from the Three

Gorges, challenges still remain regarding to how to ensure no repeat of mistakes occurred in the Three Gorges such as resettlement return, environmental degradation, and corruption.

The Danjiangkou reservoir is located on the Han River on the border of Hubei and Henan Provinces. It was built between 1958 and 1974 as the largest reservoir in China at that time. It is estimated that the increase of the Danjiangkou Dam from 162 to 176.6 meters will require the displacement of 330,000 people and submerge of 13,300 hectares (200,000 mu) of arable land during the next three years (Zhang, 2009).

The trial phase of the resettlement program was launched in the second half of 2009. Following the trial phase, the two provinces initiated the first phase of resettlement starting at the end of 2009 and 141,000 people will be relocated from their homes by the end of this year. As of June 2010, about 23,000 people have made way for the SNWTP (Liao, 2010).

The ongoing Danjiangkou resettlement marks as the second largest one in China's history, only next to the Three Gorges Dam resettlement. These two resettlements both caused a huge scale of displacement with the similar intensity. According to the official number, 1.2 million people were resettled by the Three Gorges Dam Project over ten years, which amounts to an average of 120,000 people per year. During this Danjiangkou resettlement, 330,000 people are planned to be relocated over three years, amounting to an average of 110,000 people each year. In addition, the core project sites of the two resettlements – Hubei Province for the Middle Route and Chongqing for the Three Gorges Dam Project – are very similar with regard to their level of economic development, geographic features, and cultural traditions (International Rivers, 2010).

Learning important lessons from the problems of the Three Gorges Dam Project, the Chinese government has made significant improvements on the resettlement for the Middle Route Project (International Rivers, 2010), although it is still too early to make a final conclusion. First, compensation policies are planned in more details and at levels more acceptable by migrants. The resettlement policy, for example, categorizes houses in ten types based on different construction material and purpose of usage and also takes into account as many as 16 different kinds of properties usually associated with houses in rural areas, ranging from wells and pigsties to cooking stoves. The compensation standards are also raised. Arable land, for example, used to be the combined value of the land lost and the average produce from that land during the past three years and the level now is increased up to 16 times. Overall, the resettlement budget is 32,000 RMB per person for the Middle Route Project, compared to 7,500 RMB per person for the Three Gorges Dam Project. Even taking into consideration the inflation rates between 1994 and 2009, the budget still increases by 2.3 times (International Rivers, 2010).

Second, local governments rely more on policy-oriented persuasion than simple coercion, labeling as 'human-oriented harmonious resettlement' (Zhao, 2010). For example, a large-scale campaign called '1000 Teams to Villages, 10,000 Staff to Families' was launched by the municipal government of Danjiangkou City for the trial phase of the resettlement program. In this campaign, more than 2,000 governmental employees were sent to all affected families and explained resettlement policies, resolved conflicts, facilitated cash compensations, and assisted post-resettlement activities. It was reported that these governmental employees cannot leave the villages unless their assigned families have agreed to relocate (International Rivers, 2010).

Third, post-resettlement assistance is more strengthened and more comprehensive. The municipal governments build entire new model villages with schools, clinics, general stores, and community centers. According to *Opinions on Improving Post-resettlement Assistance Policies for Medium and Large Reservoirs* released by the State Council in 2006, resettled rural people from medium-sized and large reservoirs will receive a subsidy of 600 RMB per year for as long as 20 years (China's State Council, 2006). For comparison's purposes, the average per-capita income of Chinese farmers is currently 4,868 RMB (International Rivers, 2010). In addition, the central government will provide pensions for all resettled rural people based on certain criteria. As a background, the pension funds for elderly people in rural areas are still in a trial period in China. The resettlement policies also promise free job training for at least one member of each resettled family in order to assist these families in shifting from agriculture to other sectors.

Fourth, there are seen significant improvements in the level of public participation during the Middle Route resettlement. Affected people were encouraged to elect their representatives to form a resettlement committee in each village. These committees participate in policy implementation, compensation verification, conflict resolution, the supervision of new home construction and other tasks (International Rivers, 2010). More importantly, the resettlement committees have chances to visit and evaluate the resettlement sites with travel costs paid by governments. It was reported that the resettlement sites in Hubei Province were reduced from 510 to 194 after the municipal government fully considered into migrants' opinions (Zhao, 2010). By contrast, during past resettlements in China's history, the provincial and municipal governments usually directly allocated the resettlement sites to the affected people based on some pre-conditions and people do not have any choice but accept.

However, major challenges remain including how to avoid the problem so-called 'resettlement return' or 'second resettlement' and how to ensure no repeat of the embezzlement and corruption scandals that were once notorious in the Three Gorges Dam resettlement. The return of resettled people has been a serious and widely recognized problem in the resettlement for the Three Gorges Dam Project and many other big dam projects in China (Brookes, 2000; Lu, 2003; and Doré et al., 2010). The risk remains for the SNWTP, although the governments have strengthened post-resettlement assistances. In fact, some of the older people in this region already experienced the resettlements out of their home towns in the 1960s and 1970s due to the Dangjiangkou dam project, but finally returned to the reservoir area for various reasons (International Rivers, 2010).

Of the 330,000 people to be resettled, about 230,000 will be resettled outside their municipalities and the remaining 100,000 people within their municipalities, so called 'retreat to highlands (Jiudi houkao in Chinese).' For out-of-municipality resettled people, they may suffer from different life styles and existing skills incompatible with the new environment, although they do not need to leave their home province as the resettled people did during the three Gorges Dam resettlement. For example, people are skilled in planting orange trees in their home communities find out that neither the land nor weather in the resettlement sites is suitable for growing oranges (Zhu et al., 2010). Some resettled people in Henan Province have to change their diet from noodles to rice (Demick, 2010). Neither is the so-called 'in-the-municipality' resettlement free of trouble. Most of the Danjingkou reservoir areas are dominated by agricultural activities and the population density is already very high. Resettling one third of the affected people locally could not only increase the population density in the reservoir area and impose significant pressure on arable lands, but also degrade the environment in the reservoir areas (International Rivers, 2010).

It is also a big challenge for Chinese governments to ensure there is no political corruption that was once notorious in the Three Gorges Dam resettlement. Estimates show that over US$50 million has been siphoned away by corrupt officials since the Three Gorges Dam Project launched (Doré et al., 2010). The central government has determined to tackle the problem. In April 2005, the central government issued a provisional regulation on land requisition, compensation and resettlement for the SNWTP. Zhang Jiyao, director of the Construction Committee, vowed to ensure no repeat of the embezzlement and corruption scandals. However, it is an intimidating task which is even harder than to find the best engineering diversion route for the Project, since corruption in China is thought to be endemic in economic sectors where the state is deeply entrenched.

5. Summary and conclusion

The single most prominent (and expensive) water infrastructure project in China is the country's controversial South-to-North Water Diversion Project. While this project is usually viewed through the lens of the engineering challenges, this case study focuses on the governance challenges--including how to build the institutional capacity to finance and operate the infrastructure and the provisions that have been made to ensure the project improves public welfare—especially of the populations that are being resettled due to the project.

This case study makes three arguments. First, although the SNWTP is quite a controversial solution to address water scarcity in North China, in fact the water deficits in the north are so large that neither this project nor any single alternative will provide a satisfactory solution. The decision is not only based on economic or food security concerns, but more likely on political concerns, the social stability of North China. The SNWTP is vast in size and unprecedented; its total cost could be $100 billion covering a period as long as 50 years. Extensions, notably to the west, are still in planning.

Second, as the project has unfolded it has been forced to contend with many new challenges—including water quality degradation along diversion channels, economic and ecological impacts on the source areas, a secondary salinization in the receiving areas, migration of alien species and the proliferation of parasitic diseases, and how to design diversion routes to avoid potential geological disasters (e.g., earthquakes and landslides).

Third, perhaps the largest challenge in this project has been moving beyond an engineering-dominated planning culture and building the institutional capacity needed to manage new challenges such as managing finance and a variety of ecological and human side-effects. Partial funding for the vast project is from local governments of water receiving regions. Its collection, however, is far behind of schedule. Water infrastructure is long considered to be part of the national infrastructure in China, with funding coming from central planners, and provinces were not keen to finance national infrastructure. The central government is facing the challenge of balancing conflicting interests among different provinces which all have their own administrative powers and economic interests (water receiving provinces are giving less, while water exporting provinces are asking more), while local governments is facing the dilemma of keeping water prices low to stimulate industrial growth and to subdue public opposition and meanwhile increasing water tariffs to collect the construction fund and to improve water use efficiency.

Another particular challenge has been relocating the 450,000 people displaced by this project—including the 330,000 over three years linked to the Danjiangkou reservoir. This is a resettlement with the similar intensity as the one for the Three Gorges Dam, and china is using such earlier experiences as a model for action on this project. Those lessons include detailed compensation policies, relying on policy-oriented persuasion rather than simple coercion, improving post-resettlement assistance, and significant improvements in the level of public participation. However, it remains a question mark that China could avoid the problem so-called ‘resettlement return’ or ‘second resettlement’ and ensure no repeat of the embezzlement and corruption scandals that were once notorious in the Three Gorges Dam resettlement.

VIII. Conclusions

This report looks into challenges related to how China manages its water resources with a special focus on the interaction between water and energy. It includes a comprehensive review of information about water resources and scarcity as well as the key policy mechanisms that relate to both water and energy.

In addition to a broad overview the report includes four selected case studies: 1) the development of synthetic oil from coal; 2) the setting of urban water prices; 3) China's experiments with private sector participation in its urban water sector, and 4) China's South-to-North Water Diversion Project (SNWTP). These four cases are chosen since they look at four quite distinct and important mechanisms for water governance, from the design of particular water-intensive energy projects to high capex water infrastructures and the crucial issues surrounding pricing and ownership.

This report makes three main arguments. First, water scarcity in China, notably in North China, is pressing. The scarcity is reflected not only in quantity, which is well-monitored, but also water quality where monitoring systems and governance mechanisms are much more immature. This scarcity is not just a reflection of China's geography but also a series of mismatches related to how China's planning system has allocated agricultural and industrial activities. For example, China is facing the challenge of supporting one-third of its population, cultivating two-fifths of its farmland, and producing one-third of its GDP with less than eight percent of the nation's water in the north while, at the same time, developing its coal-related industries (e.g. the power and coal-chemical industry) in coal-rich but water-stressed regions.

Second, China is undergoing five major governance changes on water resource management with both good and mixing consequences:

1) Shift from fragmented water management often called as a "multiple-dragon" system to an increasingly integrated approach which is reflected both in the rising power of river basin management commissions and in the creation of one integrated water authority at provincial levels in charge of all water related issues. This shift to integrated management is something that many studies recommend, and it probably is a good trend for China. But the case study of urban water prices disclosed that integrated management can also lead to many dangers when the integrated and powerful authorities become politicized or do not pursue good policies that reflect the true scarcity. In Shanghai, for example, newly integrated water management authorities may have been captured by special interests and adopt water prices that are much too low to signal the city's true scarcity in water supply.

2) Increasing government attention to rising natural resource constraints, particularly those to each other such as water energy nexus, in the decision-making process. The case study of synthetic oil revealed that the central government's decision to first put huge financial resources into synthetic oil projects and later to cool down its development are both rooted in

concerns on natural resource constraints. The rise of synthetic oil projects is aligned with the government's increasing concerns on energy security (constraints of oil supply), while the cool down of the projects is attributed to concerns on constraints of water and coal (no longer cheap and abundant).

3) An increasing adoption of market-based instruments such as water pricing and water rights transfer. Across China, for example, pricing has evolved from a regime where water was almost free to one, today, where in most urban cities prices are high enough to cover, at least, the operation and maintenance costs of most water supply utilities. In the last two years alone many cities significantly have sharply increased their water tariffs.

4) Reducing the role of government and seeking private sector participation, at least in a few urban settings. Reform of the water sector in China began in the 1990s in the context of broader economic reforms aimed at encouraging more private (even foreign) investment. These reforms were motivated by the huge need for investment and concern that the traditional state-centered model would lead to inadequate investment and also economically inefficient operations. However, although it is still hard to make firm conclusions about the actual experience with private ownership, the initial experience suggests that many of the problems that have appeared in the rest of the world are also identified in China (e.g. governance gaps or failures in the selection of private partners, contract provisions, cost information disclosure, and assurance of service quality). For private investors the largest challenge is the one that the fundamental conditions that allow for a sustainable private management of water resources rarely exist because water infrastructures are long-lived and costly and private investors fear changes in the regulatory environment that would undercut the financial viability of their investments;

and 5) Improving public participation in the water management decision-making and implementation. For example, compared to the Three Gorges Dam resentment, there are seen significant improvements in the level of public participation during the resettlement of the South-to-North Water Diversion Project. Affected people were encouraged to elect their representatives to form a resettlement committee in each village. These committees participate in policy implementation, compensation verification, conflict resolution, and the supervision of new home construction.

Third, the four selected case studies in this report reveal three ongoing governance challenges ahead for China's water resource management:

1) in the context of increasing decentralization in water resource management, the ability of the central government to guide the development of industry policies related to natural resources is waning. Local governments are playing a larger role and often driven by an array of pressures such as local economic growth and jobs linked to infrastructure projects that conflict with the goal of sustainable resource management. For example, the case study of synthetic oil reveals that although the central government has issued three project suspension

notices, the construction frenzy shows no signs of abating. Provinces and localities rich in coal have been highly entrepreneurial in making the best use of "black gold" polices, though some of which are quite controversial.

2) in the context of increasing private sector participation and reducing government roles in the urban water sector, the ability of local governments to protect consumer interests is weak. For example, the case study of private sector participation show that local governments have difficulty in accessing commercially sensitive information when confronted with water tariff increases proposed by private-owned water supply enterprises. Increasing privatization calls for additional effective governance mechanisms.

and 3) continued improvement of information disclosure, for example, detailed costs of water supply services, which remains a major obstacle to fuller public participation in decisions such as those surrounding water tariffs and the many side-effects of water projects such as the massive resettlement of populations displaced by the SNWTP. For example, the case study of urban water pricing shows that the public is opposed to further price increase, largely because they have no access to information on detailed service costs. People are not willing to pay what they do not understand.

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