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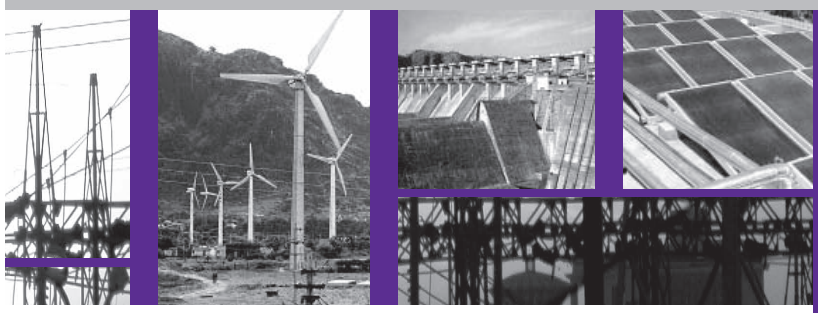

China: Development of National Heat Pricing and Billing Policy

March 2008

ESMAP

Energy Sector Management Assistance Program

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Energy Sector Management Assistance Program (Esmap)

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Funding

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Foreword

Energy conservation is a high priority for China's Government, which has set an ambitious target of reducing 20 percent of energy consumption per unit of GDP by 2010. In addition to national benefits, this will yield significant contributions to worldwide actions addressing climate change. Achieving the energy conservation target requires joint efforts of industry, government and society at large. While technical innovations will play an important role in improving supply efficiency, major changes in consumption patterns and consumer behavior are equally needed.

The Central Government's reform policies in the coal-based central heating sector and building efficiency are important for the environment and energy savings. Its proposed heat pricing and billing policy reforms will enable greater consumer control over consumption and create incentives for greater cost effective supply and efficient heat use. There is also recognition of the need for targeted heating subsidies for poor households together with heat pricing and billing reform.

Progress has been made during the last few years, especially on the heat commodification agenda described in this report, with pilot efforts proceeding in various northern cities. Tianjin became the first large city to adopt reforms to fully shift responsibility for paying heat bills to consumers. A number of medium-sized cities have also implemented this reform, and plans are in fairly advanced stages in most cities.

MOC guidelines calling for deployment of consumer-controlled heating systems within all newly constructed buildings are becoming more routinely observed. A wider variety of experiments in heat-metering technologies have been undertaken. The basic design of a new national heat pricing method has been completed, and adopted for large blocks of consumers in Tianjin for the first time in China, during the winter of 2005 to 2006.

The World Bank has been a partner in these efforts, assisting in particular on strategizing according to economic principles and on expanding knowledge in China of practical international experience in addressing the issues, especially experience from Eastern Europe, where the Bank has been closely involved in heat system reforms since the late 1980s. Engaging through an initial study on "Opportunities to Improve Energy Efficiency in Buildings (2000)," a second technical study focused on heat metering and billing options (2002). The GEF investment project—China Heat Reform and Building Energy Efficiency (2005)—provides a mechanism for supporting physical investments in new, innovative building and heating system design and construction in support of the country's heat reform and energy efficiency objectives, and related technical studies. This ESMAP-project supported a major joint Bank/MOC study, "Heat Pricing and Billing Policy," which has resulted in the design of the new national pricing method and the Tianjin piloting case.

This report provides a summary of the results of the activities completed during the two stages of the ESMAP project implemented from 2003 to 2005. It develops recommendations for the reform of heat pricing and billing, based on the outputs of this project. It reviews the proposals of the pilot

Chinese cities and national experts and, against the experiences in Western and Eastern Europe with heat pricing, recommends how heat pricing could best be reformed to achieve the objectives of heat reform in China, especially development of a more market-based and efficient heating sector that provides affordable services to consumers.

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Acknowledgments

Heat pricing reform and the introduction of consumption-based billing are essential in making heat a commodity and introducing market mechanisms to the urban heating sector. In China, however, there is virtually no experience with billing of heat according to actual use or with two-part tariffs that are commonly used in the district heating industry in most countries. With the financial support from ESMAP, this project was implemented jointly by the East Asia and Pacific Energy and Mining Unit (EASEG) of the World Bank, the Ministry of Construction (MOC) and the Municipal Governments of the pilot cities—Tianjin, Changchun, Harbin, and Taiyuan—to provide transfer of knowledge from Eastern European experience in heat pricing and support the development of a heat pricing methodology and its practical application in those pilot cities.

The Joint Study Team responsible for this report consists of Chinese national and social experts, local experts from the four pilot cities and international experts. Anke Meyer and Bernd Kalkum are the principal authors of this report, prepared under the guidance of Robert P. Taylor, the leader of the World Bank team, which also included Liu Feng and Gailius Draugelis. Liu Heming of the Urban Construction Department of MOC provided leadership on the Chinese side.

The report is based on extensive discussions among the Joint Study Team members and the following reports completed during 2003-2005:

- Guidelines for Setting Heat Tariffs, March 2003 (Bernd Kalkum)
- International Experience in Heat Pricing and Billing: Issues in Design and Implementation and Lessons Learned, September 2003 (Anke Meyer)
- Guidelines for Tianjin Team to Set Heat Tariff in the First Phase, August 2003 (National Experts Team: Chen Ming, Jiang Runyu, Di Hongfa, and Xu Wei)
- Proposal on Tianjin Feasible Heat Pricing and Billing Policy, October 2003 (Tianjin Experts Team: Qi Jinzhou, Ma Jiuxian, Wang Fuquan, Lu Yue, and Liu Yaohao)
- Proposal for a Framework for Heat Pricing in China, Interim Report, February 2004 (World Bank Team: Anke Meyer, Bernd Kalkum, Liu Feng, and Bob Taylor)
- Heat Price Management Reform—a possible outline, Memo to MOC, April 2004 (Bernd Kalkum and Anke Meyer)
- Summary on Heat Metering in Tianjin, January 2005 (Tianjin Experts Team: Qi Jinzhou, Ma Jiuxian and Liu Yaohao)
- Research on Heating Price Determination and Billing Policy in Changchun, January 2005 (Changchun Experts Team: Shi Jiusheng, Meng Jicheng and Ding Wenyong)
- Research on Heating Price Determination and Billing Policy in Harbin, January 2005 (Harbin Experts Team: Lu Qingtao, Fang Xiumu and Zou Zhiwei)
- Research on Urban Heating Price and Billing Policy in Taiyuan, January 2005 (Taiyuan Experts Team: Yang Yuan, Su Baoqing and Sun Kun)
- Study on Urban Heat Tariff Reform and Heat Tariff Policies, June 2005 (National Experts Team: Chen Dezun, Chen Ming, Jiang Runyu, Di Hongfa and Qi Jinzhou)

- Impact and Mitigating Policies of Urban Heat Reform on Low-Income and Poor People, March 2005 (Social Experts Team: Zhang Xiulan and Xu Yuebin)
- Recommendations for Heat Pricing and Billing Reform in China, Final Report to MOC, June 2005 (Bernd Kalkum and Anke Meyer)

The various reports and recommendations were discussed in several workshops between 2003 and 2005. At the final workshop in Huludao (Liaoning Province) in July 2005, cosponsored by ASTAE, the results were disseminated to participants from central government and officials and experts from almost all the northern provinces.

The valuable inputs and support to the entire project team by Hao Bin (MOC) are much appreciated. The reviewers of the interim report, Karl Jechoutek, Kari Nyman, and Apurva Sanghi, as well as Carolyn Gochenour, Peter Johansen, and Pekka Salminen, provided valuable comments, which informed the second phase of the project.

Abbreviations and Acronyms

ADB	Asian Development Bank
ASTAE	Asia Alternative and Sustainable Energy Program
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
DH	District Heating
DHW	Domestic Hot Water
EHP	EuroHeat&Power
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GEF	Global Environment Facility
HOB	Heat-Only Boiler
IBRD	International Bank for Reconstruction and Development
IFI	International Financial Institutions
MLS	Minimum Living Standard
MOC	Ministry of Construction
NDRC	National Development and Reform Commission
RBEES-95	Residential Building Energy Efficiency Standard of 1995
RoR	Rate-of-Return
SOE	State-Owned Enterprise
VAT	Value-Added Tax

Units of Measure

GCal	Gigacalorie (10^9 calories)
GJ	Gigajoule (10^9 joules)
kg	Kilogram (10^3 grams)
kWh	Kilowatt-hour (10^3 watt-hours)
m^2	Square meter
Mt	Million tons (metric)
MW_e	Megawatt electricity (10^6 watts)
MW_t	Megawatt thermal (10^6 watts)
MWh	Megawatt-hour (10^6 watt-hours)
TCE	Ton of standard coal equivalent (metric)
W	Watt

Energy Unit Conversion

1 GCal	= 1.16 MWh = 4.186 GJ
1 GJ	= 0.278 MWh = 0.239 GCal
1 MWh	= 0.86 GCal = 3.6 GJ
1 TCE	= 7.0 GCal = 29.31 GJ = 8.314 MWh

Currency Equivalents

	Local currency per US$1	
	June 2003	July 2006
EU (EUR or €)	0.86	0.78
China (yuan)	8.28	8.01

Executive Summary

Market-based reforms in China's urban centralized heating sector are essential to addressing the perpetual inefficiency of a sector built on welfare-based principles. The reform of heat pricing and billing is a crucial part of overall heat reform, since it will *commodify* heat and thus create economic incentives to provide and use heat much more efficiently. Heat pricing and billing reform requires substantial changes in four interrelated areas:

(1) Transfer of heat payment responsibility from work units to consumers, a change from invisible to visible heat subsidies and an improved targeted subsidy system;
(2) Determination of an economically efficient and equitable heat pricing system;
(3) Promotion of heat metering, consumer control of heat consumption and consumption-based billing;
(4) Improvement of the system of heat price administration.

Analytical and practical work in several pilot cities during 2003 to 2005 has resulted in the development of a heat pricing methodology that determines heat tariffs based on the full costs of the core heating business. This methodology can be used to calculate heat tariffs for unmetered customers, and it can be transformed into a two-part tariff to be used for consumption-based billing of metered customers. The methodology was adopted for large blocks of consumers in Tianjin for the first time in China during the winter of 2005 to 2006. It is also the basis for the new national heat pricing management method coming into force in late 2007. The National Development and Reform Commission (NDRC) and the Ministry of Construction (MOC) jointly issued a regulation in October 2005 to allow the partial automatic adjustment of heat prices in case of coal prices changes, an important feature recommended in the heat pricing methodology.

Applying this methodology is a first and important step to implement a more rational heat pricing system in the cities of China's heating zone. However, the methodology needs to be developed further in order to move from a transitional stage toward a fuller realization of the heat reform objectives. In particular, the incentive features for heating companies need to be strengthened.

The methodology for determining a two-part tariff was first developed for Tianjin by a team of local experts (city working group), along with national and international experts under the leadership of MOC and with funding from the World Bank's ESMAP program. The Tianjin methodology has subsequently been applied for additional case studies in Changchun, Harbin, and Taiyuan, and experts there accepted it for application. It has been broadly discussed in several national seminars and is recognized among national and municipal officials and other experts in China's heating sector as an important step forward in heat pricing reform.

The World Bank and its international experts contributed to the development of the new heat pricing methodology by expanding knowledge in China of practical international experience in addressing the issues, especially experience from Eastern Europe where the Bank has been closely involved in heat system reforms since the late 1980s. There, similar problems had to be overcome, and a slow and

somewhat circuitous process eventually led to heat pricing and billing reforms that resulted in substantial energy savings, lower heat bills for consumers, and a more efficient and commercially oriented heating industry. Heat reform in Eastern Europe was rarely the result of smooth implementation of carefully planned and sequenced interventions. Results were achieved based on trial and error rather than on comprehensive strategies aiming to reform the (district) heating sector. The analysis of the Eastern European experience and knowledge of the pros and cons of approaches and their practical implementation was an advantage to Chinese decision makers in devising a reform process that could avoid much trial and error and lead to a smoother implementation with quicker results.

China has one major advantage over Eastern Europe, in that the economy and urban incomes are growing rapidly, and major new housing and heating systems are being built. This may enable China to leapfrog and leave behind the planned economy more quickly by allowing a competitive provision of heat where possible. This would be more similar to the Western European heating sector model, which does not rely on regulation of the sector but on competition among various heating modes and fuels.

Background: Growth in Construction, Centralized Heating and Coal Use

About 250 million people live in the densely populated urban areas in China's heating zone, consisting of the cold and severe cold regions in the northern part of the country, where three to six months of space heating per year are needed, thus constituting a vital part of people's livelihood. About 70 to 80 percent of this population is served by centralized heating systems, which grew 10 times in total service area between 1990 and 2004, along with the urban construction and modernization boom.

Energy waste in space heating is enormous in Chinese buildings, which require 50 to 100 percent more energy to heat, compared to buildings in comparable climates in North America and Europe. This is in large part due to inefficient heat production and distribution and the absence of basic economic incentives for consumers to save energy. The centralized heating systems were built according to designs similar to those employed in Russia and other Eastern European countries.[1] Automation, metering, and consumer control used to be nonexistent. Technical and operational inefficiencies are far greater than in modern, energy-efficient, and demand-responsive district heating systems. Even though standards for the thermal performance of new residential buildings have existed since 1986 and were updated in 1995, a survey carried out in 2004 by MOC shows that at least 70 percent of the construction does not comply with the standards that were designed to save 50 percent of the energy required for heating.

Space heating in China is almost exclusively dependent on coal, and is fast growing. About 200 million tons of raw coal were used to heat buildings (both residential and non-residential) in northern cities and towns in 2002. This accounts for 10 percent of total energy use, 15 percent of coal use, and over 50 percent of building energy use in China per annum. Four million tons of sulfur dioxide emissions and 400 million tons of carbon dioxide (CO_2) emissions per year are produced as a result.

The urban residential building stock in northern China is expected to grow from 4 billion m^2 in 2004 to 10 billion m^2 in 2024. If heating systems would adopt modern technologies and demand-driven operations and buildings would be built according to advanced energy efficiency standards, the increase in heating coal use and relevant emissions need not follow construction growth. It could be reduced to about one third compared to a baseline scenario; see Figure 1.3.

However, until very recently, there were no economic incentives for reducing energy waste

[1] Unlike in Western and Eastern European district heating systems, domestic hot water is usually not provided centrally.

in heating systems and buildings. The urban heating sector still operated on principles set back in the 1950s, when central heating started out as a limited all-paid welfare for state employees in severe cold regions. Heating was still largely regarded as a public service supplied to urban residents as welfare, paid for by the work units (employers). Heat was not metered and billed on basis of square meters of heated area.

Centralized heating companies are under the management of local governments. They have largely been able to cover their operating expenses from sales revenues, even though at times additional government funding had to be brought in, for example, in the mid 1990s when economic trouble in state-owned enterprises resulted in very low collection rates, or during the past few years when steep coal price increases were not matched by timely tariff increases. Many companies have had problems in general carrying out maintenance and replacement of worn-out components. Expansion of heating infrastructure is routinely financed in large part from connection fees from real estate developers and, thus, ultimately by consumers.

Heat Reforms to Move the Heating Sector into the Market Economy and Reduce Energy Waste

China's top leadership is determined to reform the old heating economic system into a commercially oriented system conducive to the market economy, with a completion target of three to five years from now. In 2003, the eight involved central government ministries and commissions jointly issued "Guidelines for Pilot Projects of Urban Heating Reform," with the Ministry of Construction (MOC) designated as the working secretariat, officially launching the reform. Following two years of piloting efforts and experimentation in pilot cities in the 16 northern provinces and autonomous regions, the eight ministries issued "Instructions to Further Push Forward Urban Heat Reform," with State Council approval. In June of 2006, MOC established a new Heat Reform Promotion Office, and this was followed with instructions at the National Heat Reform Working Conference in August 2006 for localities to set up specific offices to lead implementation of municipal heat reform efforts, beginning with the development of specific action plans. Heat reform in general and the need to achieve significant energy savings in the heating and building sector has also been emphasized in China's "11th Five-Year Plan."

Heat reform involves a series of intertwined issues, all of which need to be addressed for success to be achieved. One set of issues revolves around the need to "commodify" heat through reforms in the areas listed on page 1. A second set of issues revolves around the need to reposition the heat supply industry as separate from government, including: (i) consolidation among the many small urban heating companies, developing blocks for franchising out, restructuring heating companies into proper corporate entities that can access financing for new investment, and introduction of modern heat utility operations and management practices, and (ii) development of a government regulatory and industry oversight system divorced from heating company ownership, operation, and management.

Progress has been made during the last few years, especially on the heat *commodification* agenda, with pilot efforts proceeding in various northern cities. Tianjin became the first large city to adopt reforms to fully shift responsibility for paying heat bills to consumers, including the compensation of civil servants. A number of medium-sized cities have also implemented this reform, and plans are in fairly advanced stages in most cities. In most cities, poor households receiving social welfare payments (di *bao*) under the existing social assistance system based on the Minimum Living Standard (MLS) Scheme are (partially) exempted from heat bill payments or have them partially covered from special government funds. New MOC guidelines calling for deployment of consumer-controlled heating systems within all newly constructed buildings

are becoming more routinely observed. A wider variety of experiments in heat-metering technologies have been undertaken.

The Traditional Heat Tariff System

Heat bills for all customers are currently calculated based on prices per square meter of heated area times heated area in square meters, regardless of the heat actually used. Tariffs for residential customers range between 14 yuan/m^2 per heating season in the southern part of the heating zone and 32 yuan/m^2 in the colder northeastern provinces. Tariffs for other customers are somewhat higher. In each municipality heat is typically provided by many heating companies, for example, more than 200 in large cities such as Tianjin or Shenyang and on the order of ten in smaller cities. Heat tariffs are set by the municipal governments at a uniform level for each customer group for all companies in one city.[2] In many municipalities heat tariffs were kept stable for many years, despite significant increases in input prices, particularly coal, which has more than doubled in price since 2000 to around 400 yuan per metric ton at the start of the 2005 heating season.

Average annual household heating bills range from 700 yuan to 1400 yuan, often paid at or even before the beginning of the heating period. This constitutes about 4 percent and 23 percent of the income for high-income and poor households, respectively, but since work units still pay a large share of the bill, the de facto burden is only about half of that amount. For *di bao* households with partial exemption from heat bill payments, the de facto income burden would be 9 percent, but the actual heating expenditures of poor households receiving neither subsidy nor work unit support represent on average 14 percent of their income.[3]

To promote a more rational use of heat energy, consumers need technology and economic incentives to control and regulate their heat consumption. Billing based on metered consumption would allow adjustment of heating costs to actual consumption. A new heat pricing and billing regime is necessary.

Determination of a Heat Pricing System Compatible with the Market Economy

Theory of heat pricing. In competitive markets, prices that are set equal to marginal costs best provide the productive efficiency signals. For network-based services, the marginal cost to provide the service is, however, lower than the average cost, due to the cost of building and maintaining the network. Marginal cost pricing would result in financial deficits for the service provider. A two-part pricing structure can reconcile productive efficiency and financing objectives. A price per unit set at the marginal cost of supply will preserve the incentives to produce and consume efficiently, while a fixed fee will recover the deficit. A price equal to the average costs would also eliminate the deficit but lead to a lower-than efficient level of production and consumption.

Various pricing principles for regulated network-based public services such as telecommunications, electricity, natural gas, and water supply have been developed during the past few decades that combine efficiency and financing objectives. They fall into two basic groups: cost-of-service and incentive pricing.

In the first category, cost-plus pricing is the most common pricing principle applied in the heating industry, while rate-of-return pricing was once very common in the utility sector in North America. Under both principles firms cover costs, but they cannot extract extra profits and thus have no incentive to improve efficiency.

[2] Some cities have different tariffs for heat from different generation technologies, e.g., cogeneration versus heat-only boiler (Shenyang and Changchun) or different fuels, coal versus gas-fired systems (Beijing).

[3] These data are based on a four-city survey in 2004, carried out within the scope of this ESMAP project. Official statistical information is not available, since heating is not one of the official statistical expenditure categories.

Since profits are based on costs or investments, firms have incentives to inflate them. The costs of regulation are high because tariffs need to be approved frequently when costs are changing.

Price caps are the most widely applied incentive pricing mechanism. A maximum price is set for goods or services for a certain period of time; price increases are limited to inflation (in the simplest form) minus a factor reflecting the expected productivity increase in the sector (*X* factor). Within the time period of validity of the baseline price, the firm can retain any cost savings as additional profits. At the next price review, those efficiency improvements may result in lower prices, thus benefiting the consumer. This form of price regulation requires some form of regulation of service quality that might otherwise be lowered in the attempt to minimize costs.

In practical applications, rate-of-return and price-cap regulation approaches tend to converge: Initial prices tend to be cost-based under price-cap regulation and many rate-of-return regimes use price adjustment clauses. The ability of balancing the provision of incentives to improve efficiency and to reduce costs, financing requirements, and eventual sharing of benefits with consumers makes *(hybrid) price-cap regulation* the preferred approach. Although the information requirements seem to be too complex for immediate application in a large welfare-based heating sector such as in China, it could be the *preferred approach in the mid-term*. The initial prices would be cost-based with profits based on the value of assets, and they would be adjusted over time according to an adjustment formula. The *X* factor could be set to zero initially to support the financial recovery of the sector characterized by under-capitalization on the one hand and high investment requirements on the other hand.

Practical considerations for determining regulated heat prices. The main issues to be decided in determining heat prices for a regulated industry are what the cost basis should be (this is true regardless of the pricing principle that will be applied in practice), how the profit margin would be determined, what the price structure should be, whether all heating companies should be subject to the same tariff within one city, whether all customers should have the same tariff, and how to provide incentives to suppliers and customers for efficient use of energy. While there are several choices, the decision will largely depend on the particular historical situation and institutional environment in a country.

Cost basis. The starting point for the design of heat tariffs (regardless of the pricing principle that will be applied in practice) is the analysis of the costs of providing the service. There is general agreement that all costs that can be attributed to heat supply should form the basis for heat tariff calculation—that is, costs caused by the supply of the service should be fully recovered. The relevant costs are usually those that are justified or indispensable, relating to the core heating business. Although well-defined accounting costs should be the basis for determining the justified costs, they are past costs. Since heat tariffs should cover costs in coming periods, costs and heat demand need to be forecasted as a basis for heat tariffs.

Within this project, the city working groups chose to use a mix of adjusted accounting costs and standard costs, and to use past costs. Details are on page xxv (see *Heat price determination in Tianjin and other pilot cities*). The reason for this procedure is that the many heating companies that typically exist in each city do not apply a uniform accounting framework. Costs of different companies are therefore currently not directly comparable.

Profits are remunerations for capital employed in a firm and important to attract investment to an industry. A profit related to costs creates incentives to inflate costs and efficient companies that manage to reduce costs would be punished with lower profits. Relating profits to the capital employed in a company (i.e., value of assets and working capital) creates better incentives, but it may lead to overinvestment.

For most heating companies in China, ownership of assets is unclear, and in many cases, inventories of assets do not exist. Asset values may not reflect the real values, and may have to be restated. Until ownership is clarified and the proper valuation of assets is realized,

either estimated standard asset values (similar to the approach of standard costs) or costs could be used as a basis for profits. The latter was the choice of the city working groups. They also used different profit rates for residential (lower) and nonresidential customers (higher), which results in some cross-subsidization.

Price structure. Heat supply creates fixed and variable costs, and heat demand can fluctuate substantially, even for a given ambient temperature level. To minimize the volume risk from those variations in demand, heating companies prefer to use two-part tariffs where the share of the two tariff components reflects the share of the two cost components. A properly designed two-part tariff can contribute to the optimal allocation of resources by providing incentives to consumers about energy consumption and savings through the energy charge, depending on metered consumption (kWh) and about the optimal heat load or capacity through the fixed or capacity charge, depending on the heat load (kW). Alternatives to two-part tariffs are one-part tariffs, either as a flat rate that depends only on the size of the heated area or as an energy-only tariff that depends only on the heat consumed. A flat rate tariff as it currently exists does not require metering, but also does not provide any incentives for consumers and involves substantial volume risks for the supplier. With a one-part tariff depending on consumed heat energy, consumers would have maximum incentives to save energy, but heat suppliers would not be able to match the reduction in sales with an equivalent reduction in costs, due to the fixed costs. A two-part heat tariff covering all justified costs of the heating business is considered best practice and is widely applied in Western Europe and increasingly in Eastern Europe.

All Chinese experts involved in this study supported the application of a two-part tariff. In Tianjin, the local expert group decided to base the fixed charge on square meters, since heat loads are not currently known. They also decided to use equal shares of fixed and variable charges, even though fixed costs have a slightly lower share in the cost structure. The other three cities opted for the same tariff structure as Tianjin, while in their cases variable costs are higher than fixed costs. Although interim measures may be required during the initial phases of the reform, tariff components should best follow the real cost structure as closely as possible, at least as long as consumer behavior is not known and consequences for heat supply companies and consumers cannot be assessed properly.

Number of customer groups. Not only the total heat quantity consumed, but also the structure of the heat demand (consumption pattern) has an impact on costs. In the case of lump-sum tariffs, differences in consumption are not taken into account and are thus not reflected in the heat bill. But with a two-part tariff, different consumption levels and different consumption patterns will result in different heating bills, even with the same tariff, provided the fixed part of the tariff is based on capacity (kW) rather than on area (m^2). This is another benefit of an appropriately designed two-part tariff. Although the location of a customer within a network also has an impact on costs, this is generally disregarded in tariff design because it would be too complex and costly to determine a multitude of tariffs. One tariff for all average customers is therefore generally sufficient. Heating companies conclude special contracts with negotiated prices with special customers.

In the four case studies, tariffs for residential and nonresidential customers are the same except for higher profit rates for non-residential customers. Tianjin unified tariffs for all types of nonresidential customers.

Uniform citywide or company-specific tariffs. Setting company-specific tariffs reflecting the real supply costs of each firm provides signals about the performance of the firm. Company-specific tariffs can provide better incentives to reduce costs with an appropriate tariff system than uniform tariffs. In Europe, district heating tariffs are almost universally company-specific. Benchmarking within and across cities and publication of tariffs and benchmark results is one way to exercise some pressure on management of heating companies with high tariffs to reduce costs and improve efficiencies.

Many Chinese experts favor company-specific tariffs, recognizing, however, the difficulties to implement such a system in an environment with fragmented local heating sectors and application of different accounting systems and tax treatment for heating companies. This would make the determination of specific tariffs and their supervision very difficult and costly. Thus, as a practical measure, it is clear that heat tariffs in each city will need to remain uniform during an initial, transition phase, with the possible exception of separate tariffs for different generation technologies and fuels.

Incentives for efficiency improvements. Two-part tariffs will provide effective incentives on the demand side for consumers to use heat more efficiently. Incorporating incentives for efficiency improvements on the supply side into tariff design is a difficult science. Incentive-based pricing has better properties in this regard than cost-of-service pricing (see page xxiii) and has shown good results, for example in the British electricity and water sectors. Where implementation of incentive-based pricing is difficult, at least initially, however, nontariff instruments are used frequently to improve efficiencies in the heating sector. Regulators can review tariffs and investment programs and approve them together with certain efficiency performance targets.

It is doubtful that the application in Chinese cities of uniform tariffs based on standard costs and with cost-based profits will lead to efficiency improvements. Under this system, some companies could earn profits and some would make losses, independent of their performance, but due to exogenous factors. Whether loss-making companies would actually be able to reduce costs and improve efficiencies depends partly on their financial means and the political will to effect change.

Heat tariffs, financing of heating infrastructure, and connection costs. Among all issues related to tariff design, the treatment of connection costs seems to be among the most contentious in China and in greatest need of clarification. It is standard practice within network industries to charge customers to connect their premises to a network. The actual costs would be recovered through a one-time charge—the first type of connection charge. The second type of connection charge would cover the investment costs of establishing a network and would depend on the customer's contracted capacity. Whether companies effectively require payment of this charge from their customers depends on the competitive situation. Since it is an obstacle for promoting new connections, heating companies usually avoid the second type of connection charge, at least as long as they can arrange for alternative financing, such as loan financing.

In China, the preferred sources of financing new heating infrastructure are connection fees paid by real estate developers and thus ultimately by heat consumers. In such cases, it should be ensured that such charges are accounted for properly and are considered in the determination of the tariff. A possible solution that avoids charging customers twice may be to treat depreciation of assets as a cost, and customer contributions to fixed assets as a source of revenue. This would reduce the revenue required from tariffs in order to fully recover costs.

Heat price determination in Tianjin and other pilot cities. As the first step in the approach pioneered by the Tianjin experts team, several representative heating companies are selected and their heating costs analyzed. Costs cannot be directly compared since the companies apply different accounting standards. Therefore, experts determine reasonable standards for the variable cost components (fuel, electricity, and water) by adjusting unreasonable factors and considering actual operational experiences. Depreciation is based on typical investment costs in some cities and on typical depreciation rates as percentage of fixed assets in other cities. The other cost components are weighted average costs of the selected companies. Heat supply costs are computed as average costs of the past one to three years. Taxes and profits (as a percentage of costs) are added to determine the final tariffs, expressed in terms of yuan/m^2. After establishing the fixed and variable cost shares, the variable tariff charge (in yuan/kWh) can be calculated by multiplying with

the normative average heat demand of typical buildings. Taiyuan, Harbin, and Changchun made allowances for different generation technologies, defining, for example, separate categories of heat tariffs for centralized heat from combined heat and power (CHP) plants and heat-only boilers or for customers with their own substations.

Although this approach of calculating a uniform tariff based on standard costs has many drawbacks, it is an important step forward as it is an approach to approximate a full cost recovery tariff and to decouple the determination of heat tariffs from political deliberations. This approach should, however, only be viewed as a transitory measure, since it does not result in a transparent pricing system with good incentive properties.

Heat Metering and Consumption-Based Billing

The introduction of consumption-based billing is essential in making heat a commodity and introducing market mechanisms in the heating industry. It requires that heat supply is metered, consumers can control their heat consumption, an appropriate tariff that depends on consumption is in place, the heating company is prepared or has contracted for processing metering data and issuing bills on this basis, and consumers have been informed and educated about the process of metering and billing, changes in payment terms, likely impact of metering on heating bills, and possibilities to save energy.

The issues surrounding heat metering and consumption-based billing have been discussed in China for many years. A 2002 report for the World Bank and MOC documented the experience and lessons learned from heat metering in Europe and from demonstration projects in China. One of its main conclusions was as follows:

> [Among the available metering technologies—substation- or building-level heat meters, heat cost allocators, flow meters and apartment-level heat meters], none is clearly preferable to all others. Apartment-based heat meters tend to be more reliable and accurate than heat allocation meters, but there is no evidence that their much higher costs are compensated by higher benefits. Thus a "one size fits all" approach in heat metering should be avoided. … (page 35)

Least-cost solutions for metering should be identified for both building types, i.e., energy-efficient and other buildings. The solutions will not necessarily be the same for both types; different technologies could be applied.

The main recommendation of the report—the implementation of a gradual, two-step approach in adopting heat-metering and consumption-based billing—is still considered appropriate for China:

> As a first step, it should be required to meter all buildings, new as well as existing, or at the very minimum other wholesale units such as heat substations. This will enable the basic commodification of heat [through a consumption-based bill for the building which can be divided among residents in a variety of ways] …, provide direct incentives for heating companies to improve the efficiency of heat production and delivery, and should also provide some incentives to realize energy savings on the consumption side. … (page 36)
>
> In the second step, the objective is to realize the potential end-use energy savings by adopting apartment-level heat metering, which is considered essential for motivating heating energy conservation among end-users. … (page 37)

Almost five years later, heat metering in China is still limited to mostly small demonstration projects in many cities, and only a few consumption-based billing experiments were carried out in the absence of metered tariffs. Tianjin has accumulated the most extensive experience and is now applying the two-part heat tariff for consumption-based billing in several large developments with buildings conforming to the building energy efficiency

standard. The results from five years of piloting heat metering and billing in Tianjin show that the actual heat consumption of consumers in the demonstration buildings is, on average, substantially below the norm consumption assumed by the heating companies for those types of buildings. About two-thirds of the apartments in five demonstration buildings involved in the Tianjin pilot received refunds on their heat bills, amounting to almost one third of the original bill revenue.

The experience from Europe confirms that the Tianjin results are fairly typical. Heat metering and consumption-based billing have a huge impact on energy consumption and individual heat bills. In general, a reduction of gross heat supply requirements by 20 to 30 percent is typical. Much of this can be achieved with metering at the building level, which should be widely and quickly implemented as a minimum requirement. In Poland, for example, a combination of heat metering, investments in heating systems and insulation of buildings resulted in a reduction of heating costs by about 50 percent. However, these benefits to consumers were achieved partially by severely limiting heat tariff increases, and thus by squeezing heat suppliers' revenues and profits. This negatively impacted their ability to finance investment programs.

From a public policy point of view, the main purpose of adopting heat metering is the creation of a market incentive for end-use energy conservation. This incentive to realize cost savings may directly result in energy savings. Consumption-based billing will also provide incentives for consumers to buy better, more energy-efficient apartments that are supplied by more efficient heating systems. The overall impact of a package of heat price reform and improved building energy efficiency with a growing building stock is several times larger than that of consumption-based billing in isolation. It is estimated to reduce growth of coal consumption for heating and associated CO_2 emissions over a twenty year time period by at least one third compared to the baseline (see Figure 1.3).

Heat Price Administration

Municipal agencies are currently responsible for setting heat prices and for the supervision of the local heating industry in general, while the national government is responsible for the development of methodologies and standards. There is consensus that the government should continue to be involved in setting heat prices "to restrict monopoly earnings and protect the benefits of the residents" (National Expert Report 2005), but through a more transparent, flexible, and efficient process. This process would be greatly supported by the reform of the government regulatory and industry oversight system in general in a manner that divorces it from heating company ownership, operation and management. The Bank and MOC also are beginning collaboration on this general effort.

As a first step toward more transparency, flexibility, and efficiency in price setting, the government issued a regulation in 2005 allowing partial automatic heat price adjustments in case of large coal price increases. By not depending on existing price approval procedures, such automatic adjustments should improve the cash flow situation of heating companies, provide reasonable continuity and planning security and avoid overt political influence on heat prices.

The heat price adjustment procedure is a good example for the necessity to balance the interests of heat suppliers and consumers in the process of setting heat prices. If regulators have only the interests of consumers in mind by maintaining low tariffs, they will ultimately hurt heat suppliers by squeezing their revenues and profits. This will negatively impact heat suppliers' ability to adequately maintain heat supply infrastructure and finance investment programs.

Heat purchased from CHP plants is an important cost factor in many heating systems with a significant impact on retail heat tariffs. It is unclear whether the determination of bulk heat tariffs (which involves the allocation of common costs) for which the power sector regulatory agency is responsible takes into account

the potential for energy savings from joint production of heat and power in CHP plants. It is proposed to undertake a review of the current procedures and the development of a pricing methodology for heat and power—including a cost-allocation methodology—that maximizes the economic benefits from cogeneration.

Transfer of Payment Responsibility to Consumers, Transparent Subsidies and Social Support for Low-income Consumers

For the Chinese government and experts, the introduction of consumer payment responsibilities and transparent heat subsidies constitutes a most fundamental and important part of the heat reform agenda. De facto, consumers almost everywhere in northern China are now responsible for payment of the heating bill. Only those who work for the government, public institutions (schools, universities and hospitals, for example) and organizations and enterprises that are or were state-owned may, however, be entitled to varying degrees of reimbursement by their employers. This in-kind labor compensation stems from the old welfare system for the state-owned sector, in which heating service was either provided or paid for by employers. An initial step of reform involves transferring such in-kind subsidy to an explicit cash compensation for employees when heat bill payment responsibility shifts from employers to employees. Such compensation payments are already in force for many government employees. Problems exist, in particular, for employees of financially troubled state-owned enterprises (SOEs). Workers of bankrupt SOEs join other groups of poor consumers, who then require targeted government subsidies for heating. Their heat bills can reach a high, possibly unsustainable percentage of their income (see page xxxv).

Many cities in northern China have adopted measures to subsidize the heat consumption of poor households, using mostly the existing MLS scheme, a national transfer program, for the targeting of heating subsidies. The main tools of supporting poor heat consumers are locally funded heat security funds, discounts and waivers of heating fees, and enhancement of the MLS scheme by including heat fees into the MLS benefits. Several issues need to be addressed in the future to assure the continued access of poor and low-income consumers to basic heat services:

- Municipal programs are often underfunded, since they rely on local funds only. Cofunding with the central government would be a more sustainable solution.
- Heating companies should in general not be the source of subsidy funds. This is in contradiction to a more commercial behavior. They should, however, offer more flexible, customer-tailored payment terms that would improve affordability and collection rates, especially from low-income customers.
- Only a subset of needy households get support in securing basic heating needs. Poor non-MSL households are rarely covered by subsidies. Some local governments are expanding coverage to people not covered by MLS but near poverty, such as unemployed, laid-off, and other poor people. Although a widening of eligibility criteria seems necessary, it is a challenge to maintain simplicity, so that the system does not become too complicated, intransparent, and difficult to administer.
- Especially for poor consumers a reduction of heat consumption through heat metering, controls and some basic insulation might be preferable to a reduction in heat bills. Applying subsidies to such investments or other innovative financial instruments should be considered.

Implementation of Heat Price Reform Requires a Phased Approach

The basic premise of the heat reform guidelines of the eight ministries is the necessity of the

heating sector to move from the planned to the market economy. This will require substantial changes in the organization of the centralized heating sector in China. Table 1 describes the expected changes and results (*visions*) for the issues most relevant to heat-price reform:

- The centralized heating sector undergoes a rationalization, based on municipal heat planning according to least cost and environmental criteria. This results in far fewer separate heating networks and heat supply companies in each city. Heat suppliers evolve into corporate entities, which can access financing for new investment and introduce modern heat utility technologies, operations and management practices.
- The heat price system in a commercialized heating sector is based on full cost recovery of justified costs, including a fair profit margin based on asset values with tariffs specific for each heat supply company. A price cap regime under which base line tariffs are valid for a period of three to five years and prices are adjusted automatically will provide better incentives for realizing efficiency gains.
- Consumers are responsible for full payment of heating bills. They are able to control consumption and pay according to consumption. Heat is metered in the premises of the consumer, in addition to the building level. A two-part tariff with energy and capacity charges provides incentives for consumers for energy conservation and reduces revenue risks to heat suppliers of fluctuating demand. Commodification of heat is supplemented by a system of financial support to allow low-income groups (continued) access to basic, clean, and affordable heating services.
- A system of government regulatory and industry oversight system divorced from heating company ownership, operation, and management is implemented. The regulatory framework is transparent and protects both consumers and investors. Methodologies and rules for tariff setting—identical for all centralized heating companies—are developed by a national agency. Supervision of compliance on the local level is the responsibility of local agencies.

For many of the issues, the necessary changes are quite sweeping, require substantial financial inflows for investment in heat supply systems and for targeted social assistance, and would best be carried out in several steps. This involves passing through a transition phase (see Table 1.1), where initial steps are taken to move the sector into the right direction (important examples are merging heat networks and heat suppliers, metering at the building level, introduction of two-part tariffs and partial automatic tariff adjustment), and basic requirements are put in place that are necessary to move closer to the ultimately desired results, such as enforcing compliance with uniform accounting standards, uniform tax treatment, clarification of asset ownership, and asset revaluation.

Conclusions and Recommendations: A First Important Step Toward Heat Price Reform Is Being Made—But Further Efforts Are Needed to Move Beyond a Transition Phase

The heat pricing methodology developed under this project determines heat tariffs that are based on the full costs of the core heating business. This methodology can be used to calculate heat tariffs for unmetered customers and it can be transformed into a two-part tariff to be used for consumption-based billing of metered customers.

The partial automatic pass-through of coal price increases that has recently come into force is an important advance, since it limits the need for formal tariff reviews. This will contribute to securing sufficient financing for heat supply companies during periods of rapidly increasing input costs, providing a reasonable continuity and planning security and avoiding overt political influence over heat prices.

Table 1 A Vision of the Chinese Heating Sector Reform

Current Situation	Vision	Transition Stage
Rationalization of Heat Supply		
Fragmented local heating sectors with many heat supply enterprises	Few DH companies supply DH in each city	Merging enterprises (e.g., through franchising)
Uncoordinated establishment of heat supply networks and enterprises	Sector consolidation based on municipal heat planning, based on environmental and least-cost considerations; competition for the market through bidding for supply of new developments	Preparing heat plans and business plans addressing sector consolidation
Many isolated (coal-fired) boilers with low efficiency	Small (coal) boilers are eliminated if a connection to DH is viable or are converted to cleaner fuels	Preparing heat plans (observing environmental objectives) and business plans addressing interconnection of isolated boilers and networks
DH based on outdated technologies with low efficiency	State of art DH systems (i.e., efficient, demand-driven, with variable-flow technology)	Rehabilitation and modernization investments
Heat supply companies mainly in charge of operation and maintenance	Commercialized DH companies being also responsible of financial performance, investment, and business planning	Giving more responsibility to management, creating incentives for good performance
Tariff System		
Partially subsidized tariffs	Full coverage of justified costs; targeted subsidies for low-income consumers	Gradually approaching cost recovery
Uniform local tariffs	Tariffs for each company based on individual justified costs plus asset-based profit margin	Uniform local tariff as long as sector is fragmented
Different area-based tariffs for residential and nonresidential customers	Uniform application of two-part tariffs; same tariffs for all customers except for those with special contracts	Gradual introduction of two-part tariffs with small tariff differences between customer groups due to different profit rates
No or nonspecified profit margin	Profit margin based on asset values. Some profits to be invested in DH rehabilitation and/or expansion	Profit margin related to costs; different profit margins for different consumer groups
Tariff adjustments require new approval procedures; since late 2005 partial automatic cost pass-through	Base-line tariffs will be valid for a period of three to five years; price adjustment formulas allow tariff changes without official approval	Tariff adjustments require new approval procedures; for some important inputs such as coal a partial automatic cost pass-through is allowed

Table 1 *Continued*

Current Situation	Vision	Transition Stage
Billing and Collecting		
Payment responsibility is shifting from work units to consumers	Full payment responsibility of consumers coupled with targeted social assistance for low-income groups	Gradual shift of payment responsibility from work units to consumers
Billing based on heated area/volume	Billing based on two-part tariff with energy charge based on metered consumption	Coexistence of both billing systems depending on heat meter installations; if only buildings are metered, distribution of costs among flats based on flat size
Heat metering only in some demonstration projects	Metering at building level with cost allocation based on apartment-metering/heat allocation	Minimum requirement: Building-level meters
Prepayment of heating bills with incentives for even earlier payment	Flexible, customer-tailored payment terms to improve affordability and collection rates	Prepayment of heating bills, but with negotiated payment plans
Regulation		
All collective heating systems are under government supervision	Only heat suppliers with monopolistic characteristics are subject to regulation	All heating systems are subject to regulation, as long as uniform methodologies and rules do not exist
Tariff approval by municipality	National regulatory entity determines methodologies and rules for tariff setting, municipal entities supervise compliance and regulate details	Tariff approval by municipality, based on methodologies determined by national government
Municipalities own heating companies and also carry out administrative supervision	System of government regulatory and industry oversight separate from heating company ownership, operation and management	Increased transparency of regulatory oversight (e.g., through automatic procedures)

Source: Joint Study Team.

Note: DH stands for district heating. In China it applies to centralized heating with capacities above 10 tons/h, able to supply more than 100,000 m^2.

The need to proceed with heat metering and consumption-based billing has been re-emphasized. The minimum requirement of a meter at the building level is now widely accepted for new buildings. Metering and consumption-based billing demonstration pilots should become more meaningful with the application of a two-part tariff. This will provide a better basis for gathering information on actual performance of heating systems (i.e., heat losses) and on consumer behavior. Both are necessary to properly calibrate tariffs so that heat-supply costs are covered by sales revenues.

Establishing consumer responsibility for paying heat bills is an important ingredient in making the heat market work. The government has emphasized that this component of heat reform has to be in place by the end of 2007. The implementation of plans to replace employer-provided or paid-for heat services with explicit cash payments and to extend social programs to provide heat subsidies targeted at

low-income consumers has started in many cities. With a wider application of these programs, the probability of collection and affordability problems should be fairly low.

The implementation of the proposed first steps of heat price reform is thus important in moving toward a more rational heat pricing system in northern Chinese cities. In the short term, it can be considered an acceptable compromise between continuing with the old heat pricing system and a proper cost-related two-part tariff system. However, to move from a transitional stage toward a fuller realization of the reform objectives, the methodology needs to be developed further. The most important heat pricing features to be introduced in order to achieve resource savings and other efficiency gains both in the supply and use of heat and establish a financially sound heating industry that can extend clean, reliable and affordable heat services to a growing number of consumers are the following:

- Company-specific heating tariffs. Among the most important advances to be made is the transition from uniform citywide to company-specific heating tariffs. Tariffs based on the individual costs of a heat supply enterprise cover the justified costs of individual suppliers and reflect cost differences due to differences in the management and performance of the heat supply enterprises, the use of different fuels (gas being scarce and much more expensive than coal), or different supply conditions. Thus, heat suppliers would be able to cover their operating as well as their capital costs, including the replacement of assets.
- Profit margins based on asset value are particularly important with company-specific heating tariffs. Under the alternative of cost-based profits it would be even harder to control the incentive for companies to inflate costs.
- Two-part tariffs with fixed charges based on capacity instead of square meters would provide incentives to customers to properly determine required heat demand. Such properly designed two-part tariffs would also be able to reflect the different costs of customers with different consumption levels and patterns.
- Introduction of incentive-based pricing under which properly designed base heat tariffs would be in force for three to five years with automatic pass-through of the most important cost components. This would provide better incentives for heating companies for efficiency improvements than cost-of service pricing as proposed for the transition phase.

The implementation of these changes depends on removing certain obstacles that prevent the actors in the heating sector from overcoming the welfare-based way of doing business. These are among the most important changes to be introduced as soon as possible:

- Application of uniform rules of doing business, including accounting standards and taxation.
- Consolidation of local heating sectors, taking into account municipal heat plans carried out with regard to least cost and environmental considerations.
- Licensing of heating companies to ensure that they are technically and financially able to operate a sound and efficient business.
- Completing metering of customers, at minimum at the building level and distribute a consumption-based bill at the building level among all inhabitants in a variety of ways. Consumer behavior is one of the key factors in making the new paradigm of demand-driven heating work effectively, and therefore consumer information and education must be carried out with a higher priority.
- Commercialization of heating companies including separating municipal ownership from regulation and supervision. Heating infrastructure assets need to be clearly assigned and valued properly.
- Improving the knowledge base about and within the centralized heating sector through extended data gathering as part of regular statistical surveys, analysis of metering

data, customer surveys and benchmarking of heating company operations within and across municipalities. This also requires more professional regulatory agencies on the national, but especially on the local levels.

By moving forward quickly in all areas, heat price reform can join other areas of heat reform to realize the expected benefits of substantially reduced coal consumption and improved urban environments, lower heat bills and more comfort for consumers and a heating industry which becomes a tax payer instead of requiring periodic injections of public funds.

Introduction

Importance of Heat Price Reform

Urban heating has been called the "last fortress of China's planned economy" (Deputy Minister of Construction Qiu Baoxing, cited in Xinhua News Agency, March 29, 2006). Employers still pay a significant part of heating bills for their workers, consumption is not measured and thus bills are calculated based on square meters, and energy is wasted in old heating networks and in buildings. By making the centralized heating sector function according to market economy principles and commercializing it, "Heat reform will help solve accumulated problems under the old system, such as energy waste, outdated equipment and payment delays" (Chen Wenzhan, Head of the Beijing Municipal Administration Commission, cited in China Daily, December 19, 2005). At the same time, social concerns are taken very seriously, acknowledging that low-income households need government support during the reform process (e.g., Deputy Minister of Construction Qiu Baoxing in a speech at the urban heat reform demonstration meeting, August 2003, cited in Zhang/Xu 2005).

The need to implement heat system reforms has been discussed in China for years, but put off many times due to the social sensitivity of such reforms. In the last few years, however, the country's leaders have made it clear that the reforms must proceed. In July 2003, eight central government ministries and commissions jointly issued Heat Reform Guidelines, calling for each of the 16 northern provinces and autonomous regions to implement heat reforms in several pilot municipalities.

Introducing market-based reforms to China's urban centralized heating sector is essential to addressing the perpetual inefficiency of the heating industry. The reforms are also critical to the success of another important government policy agenda: achieving sustained energy efficiency improvements in buildings. The stakes are high and the potential impact could be huge because centralized space heating is a fundamental urban service to a large and growing population in China's heating zone. Urbanization is a fairly recent phenomenon in China, and over half of the urban building stock in 2020 is yet to be constructed. The estimated net increase of centrally heated residential buildings is about 6 billion square meters over the next 20 years. Early and successful implementation of the heating sector reforms and matched progress in building energy efficiency could result in very large energy savings and economic efficiency gains in the next two decades and beyond.

Upon the request of the government, the World Bank began looking into the issues involved with energy use in the urban building sector in 1999. An initial sector analysis[4] concluded that the most effective approach to achieving sustained energy efficiency gains in the urban space heating sector is to simultaneously address critical problems in the complete heating chain from heat source through the network into the buildings and to the apartments and occupants. Simply put, policies have to address

[4] Summarized in the report *China: Opportunities to Improve Energy Efficiency in Buildings* (World Bank 2001).

the supply side (heat production and delivery) and the demand side (buildings and occupants) together. This *two-hand* approach has gained support of Chinese experts and the government and has since become the foundation for the design of a World Bank-led international assistance program, the China Heat Reform and Building Energy Efficiency Program. This comprehensive program includes a stand-alone US$18 million GEF project (World Bank 2004), a series of World Bank technical and policy analysis and advisory activities, and a proposed IBRD lending project for district heating (DH) investments in Liaoning province.

This ESMAP project—one of the World Bank technical assistance activities—has supported one of the key components of the government's heat reform pilot program. Heat pricing reform and the introduction of consumption-based billing are essential in making heat a commodity and introduce market mechanisms to the heating industry. In China, however, there is virtually no experience with billing of heat according to actual use or with two-part tariffs that are commonly used in the DH industry in most countries. Because of the similarities in DH system technology and management between current China and pre-reform Eastern Europe, the transfer of knowledge of the experiences and lessons learned in heating sector reform in general and heat price reform in particular in many Eastern European countries would benefit China in its own development of necessary reforms.

The conclusions and recommendations of this project largely coincide with those of a similar project, supported by the Asian Development Bank (ADB) and also implemented with MOC, but with different participating cities (see PA Consulting 2004).

Structure of the Report

In Chapter 1 background information is provided on the Chinese heating sector, the drivers of heat price reform are analyzed, and government heat reform initiatives and objectives are presented. Chapter 2 briefly summarizes the role of heat price and billing reforms in the overall reform of the heating sector in Eastern European countries. The experiences from Eastern Europe, where the DH sector was reformed under a more or less strict regulatory umbrella, are emphasized due to the many common features with China. In contrast, experience from Western Europe shows that DH can also develop in a commercial and competitive environment. The relevant lessons learnt from the impact of such a different sector organization are presented as well.

In the next four chapters the key principles of heat price reform, the possible choices, and their trade-offs are discussed. These chapters are based on the international experiences, the work in the participating cities (Tianjin, Changchun, Harbin, and Taiyuan), and discussions with the national experts team and a wide range of Chinese experts. In Chapter 3 the four key components of heat price reform are briefly discussed, followed by an extensive presentation and discussion of the core of heat price reform, which is the determination of the level and structure of heat tariffs that are economically efficient, can provide sufficient revenue and are equitable. The practical issues to be considered in China play an important role in the choices made by the Chinese counterparts. Chapter 4 contains a summary of options and recommendations of heat metering and billing options, originating mostly from an earlier joint World Bank/MOC project, with updates based on more recent experiences. Heat reform requires an improved system of government regulatory and industry oversight system, which is divorced from heating company ownership, operation, and management. Chapter 5 provides a brief discussion and recommendations of the regulatory issues most relevant to heat price reform, ensuring that the heat pricing process is transparent and flexible. A more comprehensive investigation of how to transform the heat regulatory system will be the topic of a new collaboration between World Bank and MOC. Last, but not least, Chapter 6 deals with the social issues of heat reform, which are in fact the primary issues to be resolved in the Chinese context—namely, shifting the responsibility for heat bill payment from employers to heat

consumers and providing some compensation for employees in general and targeted subsidies for poor consumers in specific.

The sequencing of the many actions required for the implementation of heat price reform is the topic of Chapter 7, which also summarizes the implementation experiences in Tianjin, the most extensive so far in China. Conclusions about the heat pricing reform proposals developed in the ESMAP project and recommendations about further necessary reform steps are presented in the final Chapter 8. For those unfamiliar with centralized heating technology, the annex defines some important technical concepts, which have an influence on the design of heat pricing and billing reform.

1 Background on Chinese Heating Sector and Heat Reform Initiatives

Drivers of Heat (Price) Reform

The most important aspect of China's urban heating sector development is the rapidly expanding demand for centralized heating, driven by the rapid growth in new urban housing construction. District heating (DH) systems are favored for their higher technical efficiency and improved environmental controls in serving densely populated urban areas. The broad and long-term growth aspect of DH in China, which is in contrast with Eastern Europe's stabilized DH markets, affords opportunities for reforms and experiments in new developments and facilities, similar to the development of DH in South Korea since the late 1980s. China needs to deal with the rehabilitation of deteriorated existing systems and the additional institutional complication also, especially in the northeast, but their relative importance is lower than in Eastern Europe.

Rapid Growth of the Building Stock

The urban residential and commercial building stock in China (excluding small towns) increased from 3.98 billion square meters of construction floor area in 1990 to 7.7 billion square meters in 2000. It took only four more years for the urban building stock to almost double again, to 14.9 billion square meters at the end of 2004. Between 1990 and 2004 the share of residential buildings in total construction floor area increased from 50 to 64 percent. The growth of construction area is expected to continue, albeit at a somewhat lower rate, almost doubling between 2004 and 2020 (see Figure 1.1).

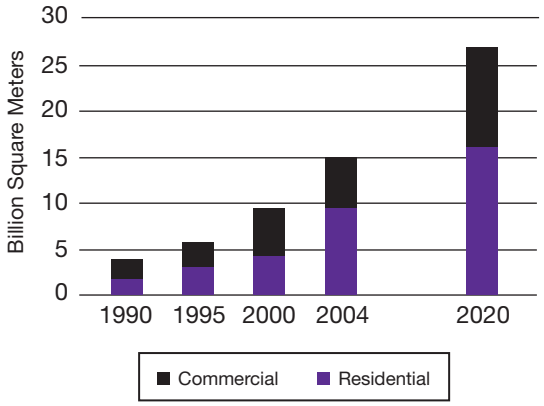
In the late 1980s, about three quarters of urban residential floor area was in low-rise buildings of three stories or less. By 1997 low-rise buildings accounted for only about one-half of the urban residential stock. The most popular new residential buildings are five to six stories high, enabling greater land conservation, but without the added cost of elevator installation, which is required by the building code for buildings of seven or more stories. In large cities or city centers, high-rise buildings are also being built, due to land scarcity. In Beijing, for example, residential buildings of 10 or more stories now account for about a quarter of the residential floor area.

Environmental Problems of Coal Use

About 250 million people require space heating for three to six months every year. Heating is almost exclusively dependent on coal. About 200 million tons of raw coal were used to heat buildings in the heating zone in 2002. This is actually the fastest-growing coal-use activity (see Figure 1.2) and currently accounts for 10 percent of total energy use, 15 percent of coal use, and over 50 percent of building energy use in China per annum. As a result, 4 million tons of sulfur dioxide emissions and 400 million tons of carbon dioxide (CO_2) emissions per year are produced. Without significant improvement of space heating energy efficiency, heating coal use and relevant emissions could double by 2020.

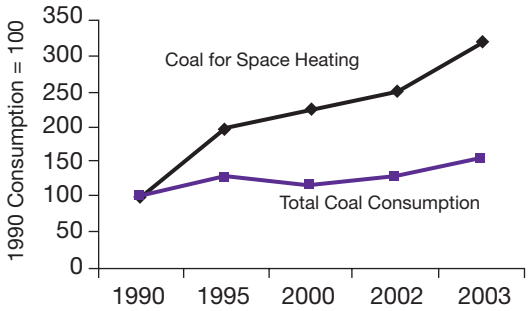
Over the next 20 years, the urban residential building stock in northern China is expected

Figure 1.1 Urban Building Stock More than Tripled in 14 Years



Source: China Statistical Yearbook 2005; 2020 estimates: World Bank Staff.

Figure 1.2 Heating Has Been the Fastest-growing Coal-use Activity



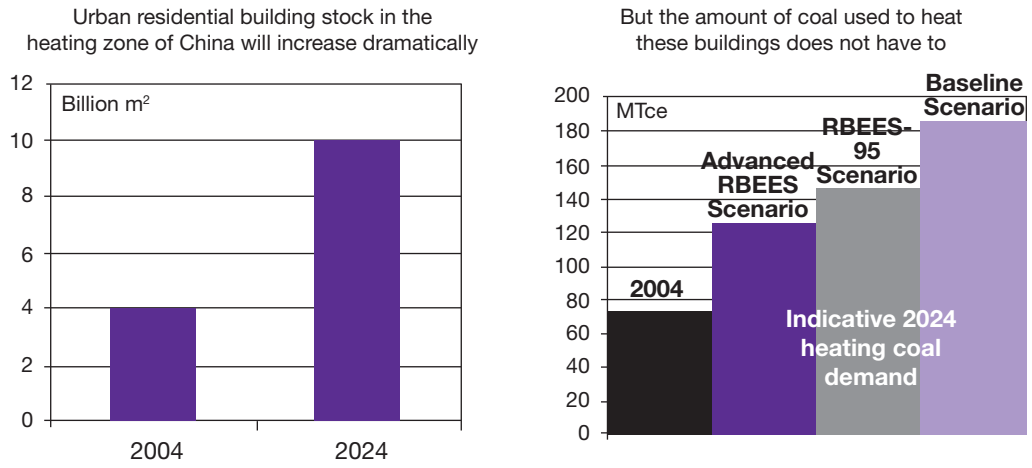
Source: China Statistical Yearbook 2005.

to grow from 4 to 10 billion square meters. Heating coal use and relevant emissions need not increase that drastically if heating systems would adopt modern technologies and demand-driven operations and if buildings would be built according to advanced energy efficiency standards. Up to 60 million tons of coal could be saved annually in new residential buildings in the heating zone (see Figure 1.3).

Replacing small boilers with modern, clean centralized heating services in city centers is important for social well being and urban livability. Many small boiler houses were built in the early stages of urbanization, and back then the placement of the boiler house in the center of the heat load was the state-of-the-art. The small boilers now find themselves in dense urban centers after strong urban expansion. The coal-fired small boiler houses in particular are a primary source of winter air pollution in China's cold weather cities. The small boilers operate at a reported 60 percent efficiency (as compared with about 75 to 85 percent for new large boilers) and use no dust or sulfur-removal equipment. In addition to its negative impact on city aesthetics (e.g., slag and coal dust in residential centers and short smokestacks belching black smoke just above the roofs of apartment buildings), city air pollution is a major contributor to chronic obstructive pulmonary disease and pulmonary heart disease, and is a factor in lowering labor productivity and increasing incidence of premature death.[5] Larger heat-generation units can better absorb the costs of pollution control equipment than smaller units.

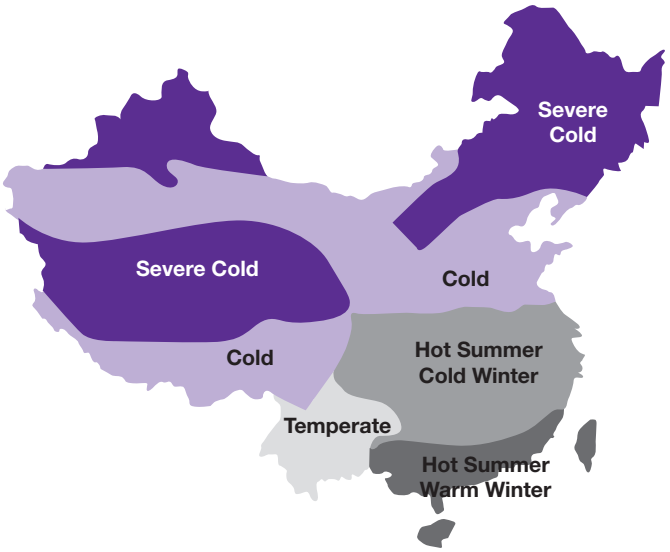
[5] Studies have estimated the damages associated with air pollution at 1.2 to 3.8 percent of GDP. Government of the People's Republic of China and World Bank. 2007.

Figure 1.3 Heated Urban Residential Building Stock and Energy Implications



Source: Liu 2005.

Figure 1.4 Climate Zones in China



Source: MOC.

The Centralized Heating Industry in China

Emergence of District Heating

Space heating is required in China's cold and severe cold regions (*heating zone*, or northern China in short), defined as regions that have at least 90 days of average outdoor temperature at or below 5°C, which cover about two thirds of the national territory (see Figure 1.4) and account for nearly half of the total residential floor area of the country. In the severe cold region, the heating season lasts more than 150 days, in the cold region between 90 and 150 days.

In the mid-twentieth century, most homes were heated with small coal stoves. Gradually, these have been replaced with centralized, hot-water radiator heating systems in areas of relatively high population density. The urban construction area supplied with centralized heating increased tenfold between 1990 and

2004, from only 0.21 billion m^2 to 2.16 billion m^2. In most cases, centralized heating began with small, *block* systems, using relatively small, heat-only boilers (HOBs) for one or several buildings. Gradually, and increasingly during the late 1980s and 1990s, larger centralized heating systems (generally referred to as *district heating* (DH)) have been developed to cover parts of most cities in the heating zone. Today, most cities in northern China have one or several major DH systems within the city center, and a fairly large number of smaller, *block* systems in the suburban areas. Use of small coal stoves is limited mostly to homes in older and smaller buildings, as well as in small cities and towns. Government policy continues to strongly promote increasing development of larger DH systems, to capture the economies of scale and reduce air pollution. Due to its major cost advantage, and shortages of alternatives, coal is expected to remain the dominant fuel for heating for the foreseeable future.

In the heating zone, about 70 to 80 percent of the urban residential building stock of currently 4.1 billion square meters is supplied with centralized heating. Coverage with larger DH systems—with capacities of 10 tons/h and above—only extends to about half of the building stock. In the large cities of the northeast, where centralized heating started early, larger DH systems typically supply more than 50 percent of the residential building stock. In the north and northwest, centralized heating started later and larger DH systems currently cover, for example, only 10 percent of the residential building stock in cities in Shaanxi and Henan provinces.

The local centralized heating sectors are typically very fragmented, with most cities having hundreds of heating companies that are under direct municipal control or under the control of various municipal organizations. Tianjin, for example, had more than 400 heating companies; the number is now reduced to about 200. The situation is similar in Shenyang and Changchun. Only very few municipalities have consolidated the sector and are now served by one or a few DH suppliers—for example, Mudanjiang in Heilongjiang province, Tangshan in Hebei province, and Yingkou in Liaoning province.

Deficiencies of Traditional District Heating Systems in China

China's centralized hot-water heating systems are based on standard Soviet-era technology except that only heat, but no domestic hot water, is provided. The advantage of these systems is that they are relatively simple and inexpensive to construct and robust to run, but they operate with low energy efficiency and allow little flexibility. Heat supply can be quite unbalanced within different parts of the system. Especially in fall and spring, open windows are an indication of excessive heat supply.

DH systems are traditionally designed and operated in constant flow mode. The water flow is kept constant whilst the supply temperature at the heat source is varied according to outdoor temperature to match the system output with expected heating need. This mode does not require flow regulation equipment and has therefore lower investment costs. In other words, the heat source regulates how much heat the customers are expected to need. In contrast, modern DH systems are operated in variable flow mode. Both the supply temperature and the water flow are varied according to outdoor temperature to match the system output with the real heating need. Flow regulation valves are installed at points of consumption and circulation pumps at heat sources are equipped with speed controls to save electricity in the variable flow mode. Heat consumers regulate how much heat they really need, and supply temperature and water flow are adjusted accordingly at the heat source (see the Annex for a more detailed description).

Energy waste also occurs due to poorly maintained and insulated pipe networks and the use of inefficient boiler technologies. Small boilers are ubiquitous and operate at a reported 60 percent efficiency (as compared with about 75 to 85 percent for new large HOBs), and use no dust or sulfur removal equipment.

In China, slightly more than 40 percent of heat-generation capacity is in CHP plants, which generate slightly less than half of the heat fed into centralized heating networks.[6] Compared with Western and Eastern Europe, this share of cogenerated heat is rather small. A share of CHP of 30 to 50 percent in total capacity, resulting in 65 to 90 percent of production, is typically economically optimal (see ESMAP 2000). In the Netherlands and Finland, about 90 percent of DH is produced in CHP mode, in Germany and Denmark about 65 percent, and in Poland and Russia the share of CHP heat is about 50 percent.[7]

Cogeneration is considered a key feature for the competitiveness of DH systems, as the high capital costs for building up the networks can be compensated by low heat-generation costs due to the high efficiency of such plants. The joint production of electricity and heat can generate energy savings between 15 and 40 percent when compared with the separate production of electricity and heat in conventional production plants.

The European Union (EU) regards cogeneration as one of the most promising and cost-effective technologies to improve energy efficiency and reduce emission of greenhouse gases. In its 2004 directive (2004/8/EC), the EU established common rules for the promotion of cogeneration, including from emerging technologies such as micro turbines and fuel cells.

In China, cogeneration facilities are typically installed where a large heat demand exists, and electricity is the byproduct. As a result, the selection of the type and capacity of the cogeneration units in China is driven by the connected thermal load rather than by electricity needs. Therefore, units with smaller capacities are usually selected. In 1999, 1,402 heating units with at least 6 MW_e per unit were operating in China, amounting to a total capacity of 28,153 MW_e, and resulting in an average capacity of about 20 MW_e. This represents 12.6 percent of the total installed capacity of thermal power, and 1,090 million GJ of heat.[8] One contributing factor to a smaller share of CHP heat is the lack of domestic hot water (DHW) supply in Chinese DH systems. In European DH systems the year-round domestic hot water supply allows the operation of CHP plants also in summer, and it spreads supply costs over more delivered heat.

Building-internal heat supply installations are also characterized by simplicity and low energy efficiency. Traditionally, vertical single-pipe systems are used where radiators are sequentially connected from top floor to bottom floor. Each apartment is thus crossed by several strings. With these arrangements the introduction of apartment-based heat meters and controls would be difficult and expensive, since each string and radiator would require them, including a bypass at each radiator. In contrast, in Western Europe and in new buildings in China pipes are arranged horizontally, so that each radiator (and DHW) source in an apartment is supplied in one single loop; two-pipe systems are standard. Apartment-based controls, typically thermostatic radiator valves, and some form of metering (see page 46–47), are a common feature almost everywhere in Europe in dwellings with centralized heating, due to the improved comfort and energy and heat bill savings they offer to consumers.

In China, even in new buildings, there is no individual heat control or measurement of heat consumption in apartments or at the building or substation level, with the exception of some demonstration projects in several cities. As in other countries using Soviet-era centralized heating technology, customers are billed each season according to a flat rate per square meter of floor area.

More generally, until very recently, heat was not treated as a commodity. Most urban dwellers supplied with centralized heat were not paying their heating bills—this was largely the responsibility of their employers. Stemming

[6] Data for 2005, compiled by MOC.

[7] For detailed information about CHP in Western and Eastern Europe, see, for example, Gochenour 2003.

[8] China Energy Conservation Investment Corporation and Energy Resources International, Inc. 2001, p. 11.

from coal subsidy programs in northern China that began in the 1950s, heat supply in major northern urban centers has been considered a public welfare entitlement. Indeed, heat supply has been the last unreformed element of the public welfare system from the time of the planned economy. Although reform of urban housing to individual ownership has proceeded strongly since 1996,[9] employers have continued to provide heating to their employees directly or by contracting with municipal heating companies. Payment levels to heating companies had generally been fairly good until the economic downturn of the mid-1990s in the northeast, when payment levels in many cities fell to around 60 percent, before generally rising to over 80 percent more recently with the adoption of tougher collection measures.

A certain amount of progress has been made in addressing the deficiencies during the last 10 years (see page 9). In many provinces and municipalities the payment responsibility is gradually being transferred from work units to heat consumers. Building energy efficiency standards are better enforced in new residential construction. Many major DH companies have adopted aspects of Western European technology in some new projects. However, heat metering, even in new buildings, is not yet mandatory. Serious energy waste in heat supply and consumption remains the norm.

Viability of District Heating

Numerous studies have shown that DH is the most cost-effective heating system in densely populated urban areas with high heat loads. The break-even point is typically in the range of 2 to 4 MW per km of network length (see ESMAP 2000). In China, the average heat load density is around 3 MW/km, varying from 1.5 in Tianjin and 2.5 in Heilongjiang to 4.7 in Beijing (based on 2004 data from 2005 Statistical Yearbook). DH is clearly a viable heating option in the densely populated urban areas of China's severe cold region. Several additional reasons are favoring DH in China:

- The clean grid-bound alternative natural gas is very expensive compared with coal and has a limited availability. For example, in Beijing, it costs about three times as much to provide one GJ of natural gas compared to one GJ of coal.[10] In Tianjin, in 2002 to 2003 it cost about 26 yuan/m^2 to produce centralized heat from natural gas, compared with 17 to 21 yuan /m^2 for coal-based DH (Tianjin experts team 2003). However, in city centers where DH from clean sources such as CHP plants located outside of the city center is not available, natural gas may be the only clean fuel for heating.
- Raw coal is the most common fuel used for heating. Burnt in individual stoves and small building boilers, coal consumption is a major contributor to serious problems with air pollution in winter. Coal can be burnt with high efficiency and low emission levels in large boilers or CHP plants, which together with DH networks provide economies of scale in emission prevention and heat supply.

Cost of District Heat and Cost Coverage

The costs of DH provision vary widely in China, depending on the severity of the climate and length of the heating season. Fuel, usually coal, is the single most important input, accounting for about 40 percent of the supply cost on average. With the dramatic increase in coal prices since 2004 to 2005 (see Figure 3.2A)—reaching about 400 yuan/t during 2005—costs of DH supply increased substantially.

In many municipalities heat prices for residential consumers have been kept stable for many years (e.g., since 1995 in Changchun). Heat tariffs for nonresidential customers are typically slightly higher than residential tariffs. It is difficult to unambiguously assess the

[9] More than 80 percent of the urban residential apartments are now privately owned.

[10] This comparison is based on a natural gas price of 1.90 Yuan/m^3 in 2004 with a gas heating value of 38 GJ/1000m^3 and a coal price of 370 Yuan/ton with a coal heating value of 5500 Gcal/ton.

degree of cost coverage of heating tariffs due to the inconsistency of the applied accounting standards. The emerging overall picture is mixed. Although detailed calculations are not available, it is estimated that cost coverage, for example, in Tianjin was about 80 percent on average from 2002 to 2003. However, an initial financial analysis of four DH companies in medium-size cities in Liaoning suggests that the majority has not been able to cover operating costs with tariff revenues during the past three to five years and relies instead on government subsidies. Independently of the degree of cost coverage, DH companies also need to make greater efforts to improve their collections. Although collection rates have increased over the dismal levels of only 60 percent in the 1990s, they are still at unsatisfactory levels of 80 to 90 percent.

Reacting to the quickly deteriorating financial situation of DH suppliers in the face of the coal price hikes, the central government issued a decree in the fall of 2005 to allow a partial (70 to 90 percent) automatic pass-through of coal price increases of more than 10 percent (see details on page 84). In many cities, heat tariffs were increased as a result; see Figure 3.2b.

Consumers of Centralized Heat–Impressions from Household Surveys

Representative statistical information on the consumption of centralized heat and, more importantly, on the consumers themselves is not officially available, since heating due to its welfare nature has until now not been included as one of the expenditure categories covered by the regular statistical surveys in China. Surveys of heat consumers were carried out in several cities in the context of heat tariff studies sponsored by both the ADB (in Shenyang, Qiqihar, Kuitun and Dezhou in 2002/03; see PA Consulting 2004) and the World Bank (Changchun, Harbin, Taiyuan and Tianjin in 2004; see Zhang/Xu 2005).

Household incomes show a wide variety across and within cities. Average annual household incomes range from about 17,000 yuan in Taiyuan and Changchun to 20,000 yuan in Harbin and 30,000 yuan in Tianjin. Within each of these four cities, the lowest 20 percent income group (quintile) has only about one-eighth of the income of the highest quintile.

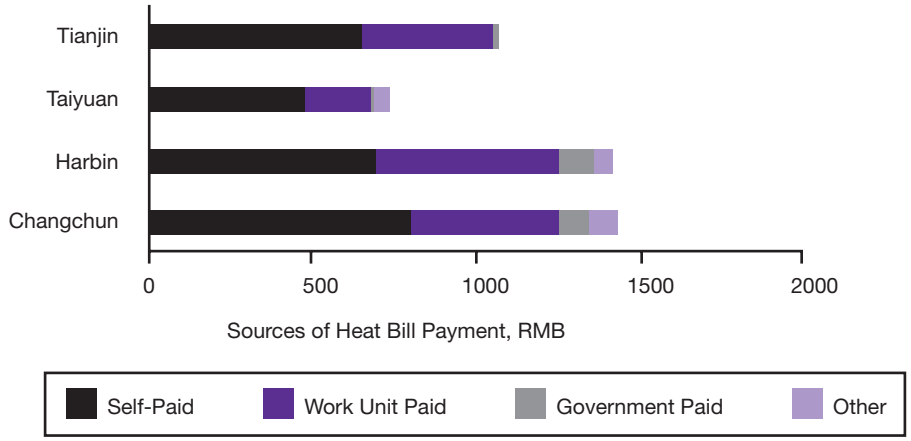
Average annual household bills for centralized heating vary only by size of the apartment within each city. Since poorer households tend to have somewhat smaller apartments, their square meter–based heating bills are lower than those of wealthier households. In general, a stronger correlation between income and heating expenses can be observed when households are connected to individual heat sources like electricity or stoves, which can be regulated. Poorer households that can regulate their heat consumption tend to heat fewer rooms and reduce indoor temperatures.[11]

Annual average heating bills of Chinese households connected to DH range from 700 yuan in the warmer southern part of the heating zone to 1400 yuan in the colder cities of northeast China. Figure 1.5 also shows how these bills were paid during the 2003 to 2004 heating season. In Tianjin, the transfer of heat bill payment to the individual households occurred several years ago (see Box 5.1), and they pay almost the entire heat bill themselves. Also, there are relatively few poor households, and thus only a small part of heat bill payments is subsidized (government paid). In the other three cities—Changchun, Harbin and Taiyuan—work units are still contributing about one-third of the payments for heating. Subsidies to poor households contribute 6 to 7 percent in Harbin and Changchun.

On average, heating bills would constitute about 4 and 24 percent of the incomes of high and low income households, respectively, but the *de facto* burden—that is, of the self-paid heating bill—is significantly smaller (see Figure 1.6). At the time of the surveys, work units in most cities still paid a large share of the bill, Tianjin being the exception. Public employees usually

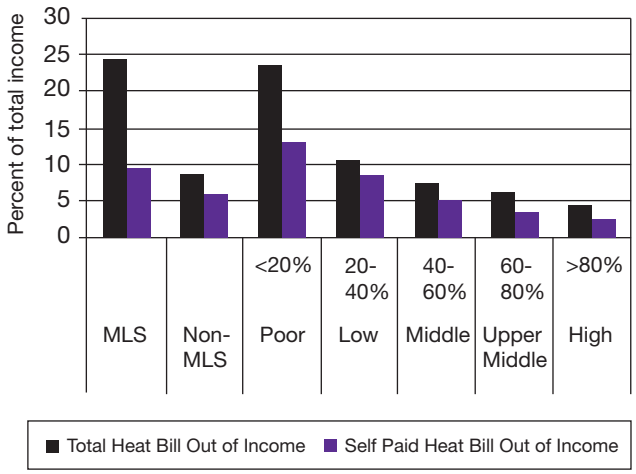
[11] See notes in Zhang/Xu 2005 and data for Armenia in Lampietti/Meyer 2002.

Figure 1.5 Annual Average Household Heat Bills (in yuan) and Their Payment Sources, 2003 to 2004



Source: Based on Zhang/Xu 2005.

Figure 1.6 Heat Bill Burden—Average of Four Cities (Heat Bill in Percent of Household Income by Income Group)



Source: Based on Zhang/Xu 2005.

obtain compensation in form of higher wages; and those poor households receiving payments under the Minimum Living Standard (MLS) program[12] are (partially) exempted from payments for heating. For MLS households with partial exemption from heat bill payment the *de facto* income burden is about 9 percent. Of some concern is the income burden of 14 percent of those poor households falling through the cracks—receiving neither heat subsidy nor work unit support (see page 69).

In Eastern Europe during the 1990s, ever-increasing fuel prices at a time of declining incomes and decreasing energy subsidies and privileges created severe affordability problems for many households, including middle class households, in many countries. Real incomes in Eastern Europe fell to only about half of their

[12] Those households are referred to as *di bao*.

level before transition started, while energy prices increased more than twofold. The price of clean fuels (electricity, natural gas, district heat, liquefied petroleum gas and kerosene) rose much faster than that of dirty fuels (coal, wood and diesel).[13] Box 1.1 shows the results of household energy surveys in Russia, Ukraine, Lithuania, and Bulgaria. Even though cost recovery at the time of the surveys was still far from complete, households paid between 5 and 20 percent of their incomes or expenditures for heat and hot water.

Conclusions. For poorer households, heat bills constitute a much larger share of income than for households with higher incomes. This is not a large problem under the traditional system with employers paying for their employees or the government paying for *di bao*. However, some poor without employment, but not qualifying for MLS payments, are confronted with heat bills they cannot afford. With the transfer of the invisible to a transparent subsidy under the ongoing heat reform and responsibility of households for payment, the problem of an unsustainable heat bill burden for low-income households becomes larger and very visible. Hence, workable subsidy mechanisms that do not neglect the problem on poor non-*di bao* households need to be devised as part of heat reform (see Chapter 6).

Box 1.1 Affordability of Heating—Results from Household Surveys in Eastern Europe

In Kiev, the capital of Ukraine, households connected to DH spent on average 6 percent of their expenditures on DH and 4 percent on hot water, a total of 10 percent, based on information from a 1997 household survey. But this share varied from slightly above 15 percent for the poorest households to 5 percent for the richest. For Kiev, the average heat tariff at the time of the survey was US$22/Gcal (which would cover the cost), and cost recovery from residential customers was about 80 percent.

Several surveys were carried out in Russia in 1995, when utility cost recovery was around 30 percent. Average housing costs (maintenance + utilities) amounted to about 5 percent of household monetary incomes. If tariffs were increased to full cost recovery levels, the share of housing costs in incomes would increase to about 15 percent. The survey results for Vladimir and Volkhov point to an average 10 percent share of housing costs in household income, and 20 to 25 percent for the poorest households.

A large household energy survey in the Lithuanian cities of Vilnius and Kaunas in early 1995 had the following results: On average, households spent 11 percent on energy (DH was about 50 percent of that), low-income households as much as 20 percent. Cost recovery was then about 30 percent.

In Bulgaria, the heat bill as share of average household income reached about 12 percent in the capital Sofia and 20 percent in Pernik. With tariffs increasing to cost recovery level by 2007, increasing incomes and decreasing average consumption due to efficiency improvements on both the supply and demand side, spending for heat is expected to decrease from 2007 on.

Source: Meyer 2003.

Heat Reform Initiatives in China

Previous Reform Initiatives

The economic reforms, which started in the early 1980s in China, accelerated economic growth, but also brought about increasing energy demand and occasional serious energy shortages. In 1986, the State Council issued a "Provisional Ordinance on Energy Saving and Management," promoting the application of more advanced and efficient technologies in all sectors, including urban heating. In the same year, a special order (No. 22) was issued by the State Council to promote DH and cogeneration, recommending the elimination of small coal-fired boilers and stoves and their replacement with DH systems. In the following decade, more than 210 CHP projects with a total capacity of 5,800 MW_e were implemented.

[13] See Lampietti/Meyer 2002.

In the mid-1990s, the central planning system was gradually replaced by a more market-oriented approach. Almost all state-owned enterprises were forced to reform and cope with market mechanisms, but many of them turned out to be inefficient and ran into financial difficulties. The heat supply enterprises, which depended on the regular payments of enterprises whose employees they supplied with heat, experienced financial difficulties too, as a result of increasing arrears from financially troubled enterprises. The situation was exacerbated by increasing fuel and electricity prices. With collection rates of only 60 to 70 percent, many heating companies could only maintain partial operation, a situation that could not be allowed in the severe cold regions. In early 1995, the State Council issued an order, demanding that local governments assist the heat supply enterprises to overcome the financial crisis. In addition, several initiatives were started to reform the heating sector. MOC selected several cities as pilot cities for various aspects of heat reform. During the next couple of years, the consolidation of the heating sector and commercialization of the heat supply companies was piloted in Mudanjiang and Yantai (Shandong province); in Tianjin the transfer of the payment responsibility from work units to households and compensation through explicit cash payments was piloted.

The welfare legacy of centralized heating, coupled with earlier financial problems of the centralized heating companies, left few choices of financing sources for additional DH infrastructure. For the time being, generation and network facilities are financed by real estate developers, and thus ultimately by consumers, through contributions to construction costs (connection fees; see para. 220ff).

Building energy efficiency improvements are an important component of heat reform. In this area, serious efforts have been undertaken during the past 20 years. China introduced its first mandatory national residential building energy efficiency standards at the end of 1995 (referred to as National RBEES-95) after limited trials of a less stringent version were carried out in selected cities between 1986 and 1995. Effective since July 1, 1996, the standard includes minimum energy efficiency requirements for newly constructed (or expansion of) residential buildings and associated central heating systems in China's heating zone. The goal of the National RBEES-95 is to reduce the specific space heating energy consumption of newly constructed residential buildings in the cold regions by 50 percent over the 1981 standard designs, by improving building envelope thermal integrity as well as heat supply energy efficiency.[14]

Implementation of the 1995 standard has been slow initially. According to official estimates, the rate of compliance in meeting building envelope thermal integrity requirements was a mere 6 percent across the heating zone in 2000. Although compliance has improved in recent years—to 30 percent, according to a 2004 survey—only a handful of northern cities, notably, Beijing, Tianjin, and Tangshan, have achieved significant success in compliance enforcement. Increased efforts are being made to systematically enforce the standard as part of the existing local procedures for construction quality inspection. Heat metering and consumption-based billing of consumers should also improve compliance by providing an economic incentive for home buyers to invest in more comfortable apartments with slightly higher first cost but significantly lower running costs.

In parallel to supporting cities to improve enforcement, MOC is elaborating a new, more stringent RBEES that would reduce energy consumption by an additional 30 percent. Tianjin and Beijing have already locally adopted such a standard. It is the basis for support under the World Bank-GEF Heat Reform and Building Energy Efficiency project (see also Box 5.1).

[14] For details see Liu 2005.

2003 Government Heat Reform Guidelines and Follow-up

After the small-scale piloting of various components of heat reform in the 1990s, eight ministries and committees jointly issued guidelines for heat reform[15] in July 2003 to scale up reform by requiring each of the 16 provinces in the heating zone to assign pilot cities and to report on progress in implementing pilot heat reform programs in those cities. These guidelines were followed up—with State Council approval—in December 2005 with "Instructions to Further Push Forward Urban Heat Reform."

The goals of the heat reform program outlined in the heat reform guidelines are to commodify heating by addressing key sector issues:

i. Shifting the responsibility for payment of heat bills from employers to consumers and transforming the nontransparent subsidy into a transparent one, including improving the system of targeted subsidies for poor consumers;
ii. Introducing heat metering and billing based on consumption, promoting consumer control of heating and building energy efficiency, including far stricter enforcement of the Government's building energy efficiency standards for all new residential buildings;
iii. Developing safe, clean and demand-responsive heat supply systems;
iv. Reforming heat pricing; and
v. Accelerating reform of heating enterprises, consolidating many small enterprises in cities, introducing competition, and fostering and standardizing the heat market.[16]

The first issue has attracted most attention so far, and several provinces and many cities (such as Tianjin, Hebei, Shanxi, Jilin, Inner Mongolia, Sinkiang, Qiqihar, Daqing, Mudanjiang, Liaoyuan and 10 districts of Beijing) have issued regulations requiring government work units to transform in-kind benefits into explicit cash payments.

The December 2005 follow-on circular of the eight ministries ("Instructions to Further Push Forward Urban Heat Reform," No. 220) underscores the need for progress in heat reform and, in particular, sets a two-year deadline for the completion of the transfer of heat bill payments from work units to consumers. In June 2006, MOC set up the Heat Reform Promotion Office (HRPO) to actively promote urban heat reform with a focus on transfer from invisible subsidies to visible subsidies and implementing heat metering. This was followed with instructions at the National Heat Reform Working Conference in August 2006 for localities to set up specific offices to lead implementation of municipal heat reform efforts, beginning with the development of specific action plans.

The second priority issue is heat pricing, triggered in particular by the coal price increases during the past three years. The MOC collaborated with the ADB and the World Bank/ESMAP on the development of a new methodology for heat pricing. The pilot city approach was used here as well, culminating in the application of the methodology in several pilot areas and the drafting of implementation documents (heat pricing management method) as the basis for applying heat tariff reform principles more broadly. The heat pricing management method was issued jointly by the National Development and Reform Commission (NDRC) and MOC in June 2007 and will become effective starting October 2007. Another result of the heat pricing work was a joint regulation (No. 2200) by the NDRC and MOC in October 2005 to allow the partial automatic adjustment of heat prices in

[15] Notice on Printing and Distributing the "Guidelines for Experimentation in Urban Heating Restructuring at Selected Places," Department of Urban Construction in the Ministry of Construction [2003] No. 148.

[16] Already at the end of 2002, the "Circular on Distributing Opinions on Quickening the Process of general adoption of the market principles for Municipal Public Utilities Sector" was issued to "promote the process of general adoption of the market principle for municipal public utilities sector. This document describes how the utility sector will be opened for franchising and concessions.

Table 1.1 A Vision of the Chinese Heating Sector Reform

Current Situation	Vision	Transition Stage
Rationalization of Heat Supply		
Fragmented local heating sectors with many heat supply enterprises	Few DH companies supply DH in each city	Merging enterprises (e.g. through franchising)
Uncoordinated establishment of heat supply networks and enterprises	Sector consolidation based on municipal heat planning, based on environmental and least-cost considerations; competition for the market through bidding for supply of new developments	Preparing heat plans and business plans addressing sector consolidation
Many isolated (coal-fired) boilers with low efficiency	Small (coal) boilers are eliminated if a connection to DH is viable or are converted to cleaner fuels	Preparing heat plans (observing environmental objectives) and business plans addressing interconnection of isolated boilers and networks
DH based on outdated technologies with low efficiency	State of art DH systems (i.e., efficient, demand-driven, with variable-flow technology)	Rehabilitation and modernization investments
Heat supply companies mainly in charge of operation and maintenance	Commercialized DH companies being also responsible of financial performance, investment and business planning	Giving more responsibility to management, creating incentives for good performance
Tariff System		
Partially subsidized tariffs	Full coverage of justified costs; targeted subsidies for low-income consumers	Gradually approaching cost recovery
Uniform local tariffs	Tariffs for each company based on individual justified costs plus asset-based profit margin	Uniform local tariff as long as sector is fragmented
Different area-based tariffs for residential and nonresidential customers	Uniform application of two-part tariffs. Same tariffs for all customers except for those with special contracts	Gradual introduction of two-part tariffs with small tariff differences between customer groups due to different profit rates
No or nonspecified profit margin	Profit margin based on asset values. Some profits to be invested in DH rehabilitation and/or expansion	Profit margin related to costs; different profit margins for different consumer groups

Table 1.1 *Continued*

Current Situation	Vision	Transition Stage
Tariff adjustments require new approval procedures; since late 2005 partial automatic cost pass-through	Base-line tariffs will be valid for a period of three to five years; price adjustment formulas allow tariff changes without official approval	Tariff adjustments require new approval procedures; for some important inputs such as coal a partial automatic cost pass-through is allowed
Billing and Collecting		
Payment responsibility is shifting from work units to consumers	Full payment responsibility of consumers coupled with targeted social assistance for low-income groups	Gradual shift of payment responsibility from work units to consumers
Billing based on heated area/volume	Billing based on two-part tariff with energy charge based on metered consumption	Coexistence of both billing systems depending on heat meter installations; if only buildings are metered, distribution of costs among flats based on flat size
Heat metering only in some demonstration projects	Metering at building level with cost allocation based on apartment-metering/heat allocation	Minimum requirement: building-level meters
Prepayment of heating bills with incentives for even earlier payment	Flexible, customer-tailored payment terms to improve affordability and collection rates	Prepayment of heating bills, but with negotiated payment plans
Regulation		
All collective heating systems are under government supervision	Only heat suppliers with monopolistic characteristics are subject to regulation	All heating systems are subject to regulation, as long as uniform methodologies and rules do not exist
Tariff approval by municipality	National regulatory entity determines methodologies and rules for tariff setting, municipal entities supervise compliance and regulate details	Tariff approval by municipality, based on methodologies determined by national government
Municipalities own heating companies and also carry out administrative supervision	System of government regulatory and industry oversight separate from heating company ownership, operation and management	Increased transparency of regulatory oversight (e.g., through automatic procedures)

Source: Joint Study Team.

case of coal prices changes of at least 10 percent in more than a year. Accordingly, heat prices in many cities increased just before the beginning of the 2005/06 heating season (see Figure 3.2b and page 62 for details).

The central government has also decided that a comprehensive regulation of the heating sector or a heat law would be needed to achieve heat reform goals and initiated a project with the World Bank/ESMAP in late 2005 to determine the contents of such regulation and best approaches to achieve heat reform goals. Detailed work is scheduled to start in late 2007.

The urgency to achieve significant energy savings in the heating and building sector through heat reform has also been emphasized in China's "11th Five-Year Plan."[17]

Vision of a Reformed Centralized Heating Sector in China

Based on the realities in China as described in the previous sections, specifically rapid urban growth and improving standard of living and environmental considerations, centralized heating will become or remain the dominant heating option in areas with high heat-load densities. The basic premise of the guidelines of the eight ministries is the necessity of the heating sector moving from the planned to the market economy. This will require substantive changes in the organization of the DH sector in China during the next decade.

Table 1.1 describes the expected changes and results (*visions*) for some of the most important issues. Moving the centralized heating sector into the market economy essentially means that heat will become a commodity with the following consequences:

- The centralized heating sector undergoes a rationalization, based on municipal heat planning according to least cost and environmental criteria. This results in far fewer separate heating networks and heat supply companies in each city. Heat suppliers evolve into corporate entities, which can access financing for new investment and introduce modern heat utility technologies (based on demand-driven operating and resource-saving principles), operations and management practices. Competition will be introduced to provide heat supply to new housing developments, for example, by requiring that the right to supply them is established through an open and transparent bidding process complying with environmental requirements.
- The heat price system in a commercialized heating sector is based on full cost recovery of justified costs including a fair profit margin based on asset values with tariffs specific for each heat supply company. A price cap regime under which base-line tariffs are valid for a period of three to five years and prices are adjusted automatically will provide better incentives for realizing efficiency gains.
- Consumers are responsible for full payment of heating bills. They are able to control consumption and pay according to consumption. Heat is metered in the premises of the consumer, in addition to the building level. A two-part tariff with energy and capacity charges provides incentives for consumers for energy conservation and reduces revenue risks to heat suppliers of fluctuating demand. Commodification of heat is supplemented by a system of financial support to allow low-income groups (continued) access to basic, clean, and affordable heating services.
- A system of government regulatory and industry oversight system divorced from heating company ownership, operation and management is implemented. The regulatory framework is transparent and protects both consumers and investors. Methodologies and rules for tariff setting—identical for all centralized heating companies—are developed by a national agency. Supervision

[17] See NDRC's "Medium and Long-Term Special Program for China's Energy Efficiency and Conservation" (November 2004).

of compliance on the local level is the responsibility of local agencies.

For many of the issues, the necessary changes are quite sweeping, require substantial financial inflows for investment in heat supply systems and for targeted social assistance, and would best be carried out in several steps. This involves passing through a transition phase (see Table 1.1), where initial steps are taken to move the sector into the right direction (important examples are merging heat networks and heat suppliers, metering at the building level, introduction of two-part tariffs and partial automatic tariff adjustment), and basic requirements are put in place that are necessary to move closer to the ultimately desired results, such as application of uniform accounting rules and tax treatment, clarification of asset ownership, and asset revaluation.

The long-term vision for the Chinese centralized heating sector is similar in many respects to the results of heating sector restructuring in Eastern Europe after a decade of transition. This is not surprising, given that the initial conditions both in terms of technologies and economy are comparable. The basic organization of the DH sector and the changes since the early 1990s in Eastern Europe and the lessons learned regarding heat pricing will be summarized in the next chapter, as well as the somewhat different DH sector organization under a more competitive model in Western Europe.

2 Heat Reform in Eastern Europe and the Role of Heat Pricing

The broad problem description and proposed reforms for the Chinese heating sector resemble, to a large extent, those in Eastern Europe during the first decade of transition. One major difference is that heat reform in Eastern Europe was rarely the result of smooth implementation of carefully planned and sequenced interventions. Results were achieved based on trial and error rather than on comprehensive strategies aiming to reform the (district) heating sector. Laws and regulations were often formulated when heating sector restructuring had already been underway for a considerable time. It is hoped that an analysis of the Eastern European experience and knowledge of the pros and cons of approaches and their practical implementation can help Chinese decision makers to devise a reform process that avoids much trial and error and leads to a smoother implementation with quicker results.

Since the end of the 1980s, the district heating (DH) sectors in Eastern European countries have experienced profound changes: In most countries,[18] including Poland, Czech Republic, and the Baltics, most consumers pay for their heat, general subsidies are mostly eliminated and have been replaced with targeted subsidies for poor households, metering and consumer controls, and consumption-based billing are more and more commonplace, many heating companies have modernized their generation plants and networks, heat suppliers are commercially oriented, and the private sector is increasingly engaged in centralized heat supply. These results are quite similar to those that are targeted by the Chinese government in its heat reform program.

Box 2.1 gives a summary of the basic pre- and post-reform features of the DH sector in Eastern Europe. In the next chapters the aspects most relevant to heat pricing will be examined in more detail to inform the recommendations for heat price reform in China.

At the beginning of the transition process, DH in Eastern Europe was typically characterized by shrinking markets due to the loss of many industrial customers, energy efficiency measures on the demand side and disconnections. The resulting bad financial status of the DH sector gave the impetus for introducing changes. Still, early in the 1990s, most decision makers were focusing on technological improvements to the Soviet-style DH systems. Urban construction has resumed by now, but most new residential construction is concentrated in small buildings, which are rarely connected to DH. Only through the integration of small isolated networks into their large integrated networks have DH companies managed to somewhat stem losses in heat demand and sales.

Heat pricing first became an issue in Eastern Europe when the first DH modernization projects were cofinanced by the international financial institutions (IFIs) in the early 1990s. The IFIs requested that the technical rehabilitation be accompanied by a significant and steady increase of the tariffs to improve the financial status of the DH companies and enable them to pay back the loans. This happened, for example in Poland, where the World Bank provided loans

[18] With the general exception of countries in the Commonwealth of Independent States (CIS).

Box 2.1 District Heating in Eastern Europe

Early 1990s

- Many heating companies in each city
- Many small (coal) boilers and networks; small share of cogeneration
  and larger share of cogeneration
- No incentives for efficiency improvements and energy savings
- Heat is not metered and cannot be controlled; lump sum tariffs are based on square meters
- Mostly state-owned companies; often owned by state-owned-enterprises to supply employees or part of the national power supply system; transition to municipal ownership
- One tariff for residential buildings in one city or even the entire country, does not recover all costs
- Most companies make losses
- Heat is considered welfare; work units pay bulk of heating costs
- All residential consumers receive subsidized heat
- No competition in the heating sector

Currently in Most Advanced Countries

- In each city: One to few companies that provide centralized heating
- Small boilers integrated into large DH networks
- Energy savings and other operational and commercial efficiency improvements are promoted by heat pricing and management reforms
- Heat is metered and can be controlled by consumer; heat bill depends on consumption; both two-part tariffs and one-part tariffs with energy charges only are applied
- Many different ownership forms with regulation of DH suppliers by independent local or national agency
- One tariff for each heating company—recovers all justified costs
- DH is becoming a profitable business
- Consumers are responsible for full payment of heat bills
- Only low-income families receive targeted subsidy
- Shrinking market for DH: loss of industrial consumers, improved building energy efficiency, temporary disconnections due to competition from other heat sources and affordability problems

Source: Meyer 2003.

to five cities for DH improvements (see Box 2.12 and 3.1).

In the beginning of the reform process, heat pricing was mostly an instrument to bring heat prices closer to production costs that had suffered substantial increases due to fuel prices rapidly approaching world market price levels. The tariff level was simply increased without changing the tariff system itself. Tariff regulation used to be a political instrument to prevent "excessive" price increases aiming to avoid harmful social and political consequences. The main task of the regulatory entities became safeguarding consumers' interests (through low prices), but it was not used as a means to reform the whole sector and to improve the performance of the DH enterprises. Only recently have heat pricing and tariff regulation in some countries become an active instrument to develop the heating sector.

Nevertheless, heat price reform, even in its most basic form as increasing heat-price levels to better reflect supply costs, together with the technical modernization of heating systems and management reforms, has resulted in a comprehensive, but still ongoing remodeling of the heating sectors in Eastern Europe. The degree of success of pricing reform and technical

modernization varies significantly from country to country. It is evident that clear visions of the future of the DH sector (such as in Lithuania) helped accelerate the commercialization process and achieve systematic improvements of the sector, while the lack of visions (e.g., in Romania, and for a long time in Bulgaria) contributed to deadlock and eventually the decline of the sector.

Studying this experience from Eastern Europe can help China avoid costly mistakes. An important lesson is that the development and implementation of a systematic heat reform strategy could save time and money. Another lesson is to avoid the vicious circle of heat tariffs falling below cost recovery levels, leading to severe declines in service quality by cash-strapped heat suppliers, unhappy consumers, deteriorating collections and further decline in service quality, observed in many heating systems in Eastern Europe. The early implementation of heat metering, consumer controls, and consumption-based billing, together with two-part tariffs at cost recovery levels, will provide incentives for households to use heat more efficiently and will force heat suppliers to adopt technical and operational measures to cope with the demand-driven changes. Such improved performance of the centralized heating systems to make them efficient, flexible, and cost-effective should result in satisfied consumers who appreciate the comfort provided and are willing to pay for the service. Finally, early implementation of an effective system of targeted subsidies to low-income consumers needs to supplement the heat reform measures.

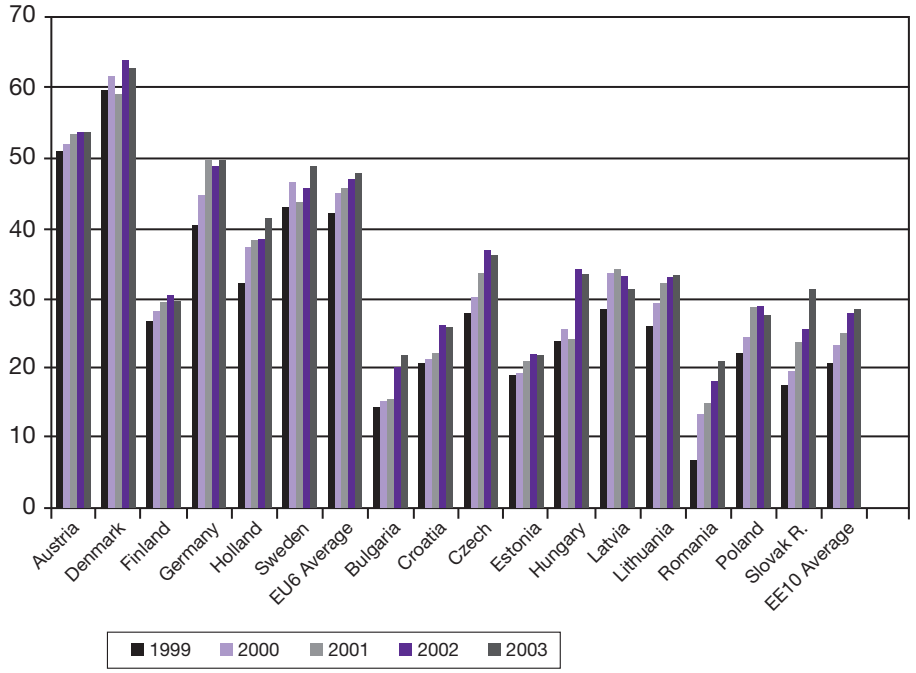
Knowledge transfer from Eastern Europe is emphasized due to the similarities in the initial conditions and the need for a well-defined reform process. In some aspects, however, China is characterized by more favorable conditions than Eastern Europe, specifically economic growth and income growth of the urban population with resulting construction boom and improved living conditions. This may enable China to leapfrog and leave behind the planned economy more quickly in favor of approaches that maximize the benefits of competition in the heating sector (i.e., consumer-oriented, efficient, clean and affordable heating). This would be relevant mostly for new housing developments. For example, developers could bid out infrastructure supply in general and

Box 2.2 District Heating in Western Europe

- DH is mostly under municipal control and dominated by municipal utilities, but private ownership is increasing.
- Even though distribution of DH is considered a natural monopoly, DH is operating in an inherently competitive environment, since alternative heating methods (based on natural gas, light heating oil, electricity) have always been available to customers.
- Unlike electricity or gas, DH is generally not subject to regulatory oversight, including price setting. Exception: Denmark
- DH connection is based on contracts in accordance with commercial codes.
- Prices are uniform for residential consumers within a DH supplier's market; prices for larger commercial, public, and industrial customers are negotiated between customer and supplier.
- In most DH systems, two-part tariffs are applied.
- Changes in heat prices are usually proposed by the DH company and approved by its board.
- Consumer protection is carried out by anti-monopoly or competition offices.
- EU policies targeted at promoting combined-heat-and-power (CHP) generation are also indirectly benefiting DH.
- With energy costs on average only about 4 percent of household income, only a very small percentage of low-income households are eligible for targeted social benefits that include payments toward heating bills.

Source: Meyer 2003.

Figure 2.1 Estimated Average District Heating Prices in Europe (1999 to 2003) in Euro/MWh, without VAT



Source: Werner 2006.

heat supply in particular within the limitations imposed by environmental and heat planning.

Under these conditions, the experience from centralized heating in Western European could become more relevant for China. Here, DH is not regulated,[19] since it is operating in a competitive environment where alternative heating methods based on natural gas, light fuel oil, and electricity have always been available to consumers. Box 2.2 lists some of the relevant features of DH in Western Europe, which will be elaborated in later chapters.

Weighing these two examples, it is recommended to regulate the Chinese DH industry, at least during a transition period, since little competition is expected in the centralized heating market in the short and medium term. Consumers are just starting to become responsible for heat payments and may therefore need extra protection from potential monopolistic behavior when entering contracts with heat providers. In the mid- to long-term, however, in cities where multiple options for space heating are available, regulation should be as minimal as possible, with market-based DH prices set in competition with other heating options.

A comparison of average DH prices in Western and Eastern European countries (see Figure 2.1) provides little evidence that the mere existence and type of regulation have any significant influence on the price level. For example, Denmark, the only country within the EU6 countries where DH is regulated, has higher prices than all other EU6 countries where DH is operated under competition. Obviously, other factors play a more significant role. Climatic factors are important, as the fixed costs (capital costs) per heat unit (MWh) go down with the

[19] The only exception is Denmark where prices are regulated, since most DH customers have been connected according to governmental planning initiatives (see Werner 2006).

length of the heating period. This fact contributes to low DH prices, for example, in Finland. In all listed Eastern European countries the DH sector is subject to regulation, including DH pricing. Heat tariffs are rather different, ranging from 20 to almost 40 €/MWh. Lithuania and Czech Republic are the two Eastern European countries with a rather advanced privatization in the sector. Both countries have among the highest tariffs in this group.

In some of the countries in Eastern Europe, the increases of DH prices during 1999 to 2003 reflect policy decisions to bring energy tariffs closer to cost recovery levels (e.g., in Bulgaria and Romania). It also reflects the establishment of regulatory agencies that are less prone to consider political motives in their tariff decisions. Thus, DH tariffs do not necessarily reflect the real production costs, but, rather, the competence and willingness of regulators to approve reasonable tariffs.

An isolated comparison of prices does not allow us to draw any conclusions about costs of heating. A high heat price can reflect the high investment costs of a very efficient system that also reduces heat supply and heat consumption while improving the comfort. Thus, resulting heat costs could be lower than in a system with lower average costs and prices but lower efficiencies. But of course, a high heat price can just reflect the inefficiency of an outdated, badly managed system.

Heat Pricing: Key Principles, Requirements, and Determination of Regulated Heat Prices

Basic Principles of Heat Price Reform

In line with the objectives of the overall heat reform guidelines (see page 11), the objective of heat price reform in China is to improve the overall efficiency of the heating industry so that it gains a sound financial footing and provides affordable access to clean heat services for consumers. The following principles to be applied to heat prices have been uniformly agreed by the joint study team. Heat prices need to

- provide incentives for the efficient supply and use of heat;
- enable heat supply companies to operate on a sound financial basis, and
- be set in a clear and transparent way, making the tariff system easily understood especially by final consumers.

In the Chinese context the realization of the heat price reform objective and principles requires that measures in four main areas are undertaken (see, for example, National Experts Report 2005):

1. Introduction of consumer payment responsibility and a change from invisible to visible heat subsidies. This includes the transfer of payment responsibility from work unit to consumer and compensating cash payments. For poor and unemployed consumers social assistance for payment of heat bills needs to be provided.
2. Determination of the justified heat price: What should be the basis for the tariff? How do cost and price relate? How can tariffs provide incentives for efficiency improvements? How would tariffs be structured for different heating companies and for different customer groups?
3. Promotion of heat metering, consumer control of heat consumption and consumption-based billing: What is the best tariff structure appropriate for heat metering that meets the interests of both supplier and consumer? What types of heat meters should be used and what would be the implications for consumption-based billing schemes? Should new energy efficient buildings and existing buildings be treated in the same way?
4. Improvement of the system of heat price administration: How can the monopoly power of heat suppliers be reigned in

and political influence on tariff setting be avoided? Coordination between power, bulk heat, and heat pricing is necessary. Partial automatic tariff adjustment formulae should be used.

Caveats and Requirements

Based on this general agreement about the principles of heat pricing, it is obvious that a tariff system incorporating those principles and requiring substantive changes from the current practice in China will deeply affect not only suppliers' business practices, but even more so consumers' pocketbooks and behavior. Many steps have to be taken to design and implement a heat pricing system that is suited for a market economy. It should, however, also be acknowledged that some steps could be taken quickly and/or that some municipalities or types of buildings could move at a faster speed and in a flexible manner, especially in the case of new housing developments.

In addition, the implementation of a more rational tariff system is hampered by the existence of a very fragmented heating sector. Tens (in smaller cities) or hundreds (in larger cities) of heating companies of different sizes and with different owners supply heat within a municipality. The historical development of the Chinese heating sector has led to a veritable jungle of cost accounting rules and different tax regimes, depending on ownership and corporate structure and to a mix of actual and normative costs in the determination of heating costs. Uniform accounting standards for business enterprises were issued in 2001, and in 2005 the Ministry of Finance issued a regulation making them applicable also for state-owned enterprises (SOEs) in a gradual process. The compliance with the standard is, however, not enforced and SOEs' accounts are not externally audited. In addition, the applied accounting rules usually do not allow to identify the costs for individual products or services (such as hot water for space heating, domestic hot water, steam, etc.) and activities (generation, transport, distribution, heat transfer to buildings, etc.). Prices and tariffs thus do not properly reflect the actual costs and provide misleading signals to suppliers and consumers. A rational tariff system requires that the accounting costs of heat supply are determined uniformly in a clear and transparent fashion and that taxes are applied uniformly across the sector.

Other hurdles are the lack of clear ownership and proper valuation of heat infrastructure assets. These and other problems should, however, not be an excuse for not moving ahead with reform. In many cases, first best solutions will not be implemented right away, but instead, transitional solutions will be employed while the basic prerequisites for deeper reform are being put into place. The decisions about the choice of instruments will thus largely depend on the particular historical situation and institutional environment in China. Table 2.1 lists the most important issues to be decided in the four areas of heat price reform and possible alternatives which will be discussed in detail in the following chapters.

In the remainder of this chapter, practical recommendations for the core issue in heat pricing—the determination of structure and level of heat prices—are developed based on Chinese conditions and expected developments and informed by the experience of reforming heat prices in Eastern Europe. The other three areas described at the beginning of this chapter will be examined later.

Determination of the Regulated Heat Price

The core of heat price reform is the determination of the level and structure of heat tariffs that promote the objectives of heat reform. The ESMAP project focused on the determination of retail heat prices. Most heating companies in China generate the heat they supply to consumers. Exceptions are heating companies that source bulk heat from large combined heat and power (CHP) plants. The pricing of CHP heat requires an analysis of the cost allocation

Table 2.1 Alternative Approaches to Heat Price Reform Issues

Issues	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Pricing principle	Cost-of-service based	Incentive based		
Cost basis	Accounting costs	Standard costs	Future costs	Justified costs
Profit margin	Cost-based	Asset/capital-based		
Customer/ Tariffs groups	One	Differentiated		
Price structure	Fixed, lump-sum	Consumption-based: One-part	Consumption-based: Two-part	
Scope of tariffs	Uniform in each city	Individual for each heating company		
Metering	Substation-level	Building level	Apartment level	
Consumption-based billing	With compensation factors	Without compensation factors		
Extent of compensation	Complete	Partial	None	
Approach to social assistance	Only for MLS beneficiaries	Extend to non-MLS poor		
Financing of social support for heating	Financing from heating company	Financing from local government	Financing from central government	Shared
Heat price administration	Central regulator	Municipal regulation	Shared responsibilities	
Tariff adjustment	Basic procedures with approvals, hearings etc	Automatic adjustment formulae		

Source: Authors.

between heat and power.[20] Frequently, it is determined by the relative negotiating powers of supplier and customer. Bulk heat and CHP pricing would therefore have required an additional level of analysis and involvement of a range of additional stakeholders that could not be accommodated in this project, but is expected to be the subject of a subsequent analysis.

The following section reviews the theoretic basis of price setting in regulated infrastructure

[20] For a comparison of different cost allocation methods see Gochenour 2003.

sectors and the discussion about cost-of-service and incentive pricing, before turning to the practical application for the Chinese centralized heating sector.

Functions of Regulated Prices and Pricing Principles

In regulated industries with (natural) monopoly characteristics (see footnote 22), prices do not result from the interaction between supply and demand, but they are based on regulatory decisions that intend to approximate efficient, competitive outcomes. In addition to efficiency objectives, regulators pursue financing and equity objectives with their price setting decisions. The main functions of an efficient price setting system[21] are thus to

1. Provide signals about the scarcity of services (allocative efficiency) so that consumers use heat efficiently, and suppliers produce it as efficiently as possible (productive efficiency);
2. Ensure that heat suppliers earn sufficient revenue to cover their operating costs and future investments (financing objective); and
3. Ensure a fair distribution of benefits between members of society (equity objective), between service providers and consumers (for example, ensuring that the cost savings from modernization and efficiency improvements are shared and do not accrue solely to the provider) and between different classes of consumers (for example, setting prices in such a way that low-income consumers can access the service).

A pricing system will best achieve these objectives if it is transparent so that consumers can easily understand their bills and react to pricing signals. Finally, regulators must pay attention to the quality of services so they are provided at an agreed level and do not deteriorate in the pursuit of efficient production. For an overview of quality of service issues in utility regulation see, for example, Holt 2004.

In competitive markets, prices that are set equal to marginal costs best provide the productive efficiency signals. For network-based services, the marginal cost to provide the service is, however, lower than the average cost—due to the cost of building and maintaining the network.[22] Marginal cost pricing would result in financial deficits for the service provider. A two-part pricing structure can reconcile productive efficiency and financing objectives. A price per unit set at the marginal cost of supply will preserve the incentives to produce and consume efficiently, while a fixed fee will recover the deficit. A price equal to the average costs would also eliminate the deficit but lead to a lower-than-efficient level of production and consumption.[23]

To achieve the equity objective it is frequently necessary to supplement pricing measures[24] with other measures such as targeted social assistance (see Chapter 4). Preference should be given to those supplementary measures that preserve the other two objectives.

Various pricing principles for network-based public services such as telecommunications, electricity, natural gas, and water supply have been developed during the past few decades that combine the efficiency and financing objectives. They fall into two basic groups: cost-of-service and incentive pricing.[25] These two approaches and their basic pros and cons are summarized in Table 2.2.

Cost-of-service regulation sets prices that are based directly on the costs of the regulated firm. *Rate-of-return (RoR) regulation* was once very common in the utility sector in North America. The regulator determines a *fair* return on capital assets and then sets prices to deliver this outcome. The objective of RoR regulation is to ensure that prices are set at a level that allows

[21] See, for example, McCarthy Tetrault 2000, for the telecommunications sector.

[22] This fact constitutes the "natural" monopoly: one single supplier can supply the entire market at lower cost than several suppliers.

[23] See, for example, Berg/Holt 2001.

[24] In the electricity sector life-line tariffs are frequently used for this purpose; see, for example, Lovei et al. 2000.

[25] For comparison of regulatory pricing approaches see, for example, McCarthy Tetrault 2000.

Table 2.2 Cost-of-service Regulation versus Incentive Regulation

	PRO	CON
Cost-of-service-regulation	Firm covers actual costs, but cannot extract excess profits.	Firm has no incentives to operate efficiently and has no or only very small opportunities to accumulate equity capital.
	Consumers immediately benefit from efficiency and performance improvements.	Information requirements are substantial. Costs of regulation are high due to frequent approval procedures (including hearings etc.).
		Delays in tariff approvals can generate high losses, especially with high inflation rate or high input price increases.
		Subject to direct political intervention through the regulatory or price setting authority.
1. Cost-plus	Information requirements are limited to expenses/ costs.	Profit is based on costs –> firm has incentives to inflate costs; efficient companies that reduce costs are punished by lower profits.
2. Rate of return	Investors are offered guaranteed returns.	Profit is based on assets/ investments –> firm has incentives to overinvest. Requires additional information on capital/ asset values which are especially difficult to determine in economies with (past) high inflation rates.
Incentive regulation	Provides incentives for cost minimization and managerial efficiency since firm retains profits due to efficiency improvements.	Companies need to be capable and have access to capital to exploit opportunities for cost reduction and efficiency improvements. Service quality may deteriorate unless quality of service is regulated as well (remedy: performance standards with penalties and rewards; establishment is data intensive).
	Information is used more effectively by regulator.	Information requirements are even more substantial for initial price approval than for cost of service regulation and determination of productivity factor is complex, but no frequent approval procedures required.
1. Price cap		Consumers do not benefit from lower costs before the next approval of a baseline tariff.
2. Price cap with adjustments for exogenous changes in input prices	Consumers benefit partially from greater efficiency and lower costs.	

Source: Authors.

ongoing supply of the goods or services by the regulated company, but are not set so high as to allow excess profits.

Cost-plus pricing is widely applied for public services regulation in Eastern Europe. Under cost-plus pricing, the tariff calculation is (ideally) based on the company's future revenue requirements (i.e., recovering its full cost of operations and allowing for income to pay taxes, dividends, finance the rehabilitation of existing and construction of new assets). The main flaw of this approach is that in practice, it is usually aimed at the recovery of invested assets, but does not adequately reflect the needs for future development of the infrastructure. In addition, the allowed profit is typically a share of the total cost, creating an incentive to inflate costs and thereby increase profits. Companies that are efficient and manage to reduce their costs would be punished by a lower profit.

The information requirements for both variants are high, but in a well-managed company, the necessary information should already be available to the management. For cost-plus pricing, the main problem lies in the determination of the *justified costs* of each regulated company. For RoR pricing, the regulator—using information provided by the firm on its projected operating and capital costs, asset base, and projected sales—must determine what constitutes a fair rate of return (including an assessment of risk), whether the operations and proposed investment are efficient, and then what would be appropriate unit prices over the regulatory period. Since there is information asymmetry between the firm and the regulator, the firm has a huge incentive for inflating costs and/or investment.

The fundamental problem with RoR regulation is that because the regulation is effectively cost-plus and because prices are typically reset on an annual basis due to changes in the costs, the regulated firm will not benefit from reducing costs as any resulting savings are passed on to the customer. There have been attempts to improve the outcomes from cost-based regulation. Benchmarking techniques have been applied to overcome information problems inherent in RoR regulation, though with limited success. Another approach has been profit-sharing (or sliding-scale) regulation, which is a variant of RoR regulation.

An alternative to checking the individual costs in detail is the *benchmarking* approach, which compares the costs[26] of an individual heat supply company with industry benchmarks. The first issue is the decision of which benchmarks to use: the average costs of the industry, the costs of the "best" company, costs of a theoretical green field company, and so on. Simple benchmarks, such as costs per MWh, staff per km pipe, or fuel consumption per MWh fail to take into account the specific peculiarities of an individual DH system. Sophisticated benchmark systems are complex and costly. The main concern about the benchmarking approach is that it assumes that high costs are caused solely by inefficiencies and bad performance.[27] Under a benchmarking approach, tariff adjustments will be required if the benchmarks change or if input prices change in case only physical benchmarks are used.

In view of the poor incentive for productive efficiency of cost-based regulation, other forms of regulation have been developed. These attempt to provide regulated firms with appropriate incentives for efficient supply and price structures, while at the same time encouraging firms to implement efficient price levels (and earn normal profits) over time. As summarized by Vogelsang (2001): ". . . [incentive-based regulation] means that the regulator delegates certain performance-related decisions to the firm and that the profits of the regulated firm depend on performance measures of the regulator. Incentive regulation

[26] Costs can be expressed in monetary terms (e.g., $/MWh), as well as in physical terms (kg of fuel per MWh).

[27] For example, high distribution costs can be caused by (i) high heat and water losses, but also by (ii) an extensive network due to a low heat density. Fixing the approved distribution cost in accordance to a lower benchmark may promote investment in pipe replacements in case (i), but it would not help to reduce the costs in case (ii) except by closing down the whole or at least a part of the network. Whether the latter would be viable has to be tested by a least cost study; it cannot be answered by benchmarking.

makes use of the firm's information advantage. The regulator thus controls less behavior but rather rewards outcomes."

Price-cap regulation is the most common form of ***incentive regulation***. Here, the maximum price for a bundle of goods or services provided by the regulated industry is specified for a certain period of time. Typically, price increases are constrained to a level determined by an index—commonly the rate of inflation (RPI, which serves as a proxy for exogenous rises in the prices of inputs)—minus an *X* factor that (predominantly) accounts for expected productivity improvements in the regulated industry (RPI-X). Any cost savings achieved beyond the performance-adjusted rate of inflation accrue to the firm within a given regulated period, usually three to five years, thus creating incentives to reduce costs. After the end of the period of validity, the price cap is reviewed and adjusted downward (see also the note below on the price-cap approach in the UK water sector).

Although price-cap regulation has important incentive features and can reduce the cost and complexity of regulation, it has some drawbacks:

- To avoid that the costs savings are generated by reducing the service quality, the service quality has to be supervised as well, leading to quality of service regulation.
- The procedure for determining the initial price is basically the same as for cost-based regulation, but more difficult as the impact of accidental factors should be eliminated.[28] This is especially true when there is only limited measurement of inputs and outputs, common in the DH industry in transition economies.
- The most disputed element of this regulation is the determination of the X factor, expressing expected productivity improvements.[29] A rational determination of the X factor requires a comprehensive knowledge base of the regulated sector and its development opportunities. It is interesting to note the price-cap approach in the English and Welsh water sector: Increased investment to improve water quality with a resulting increase in water prices was expected, and therefore a price cap scheme of $RPI + K$ was devised, where $K = Q - X$, with Q the cost of meeting quality targets (see Klein 1996).
- Service providers bear a larger share of risk under price-cap than under RoR regulation (where consumers share in some of the risk) and therefore face a higher cost of capital (see Alexander/Irwin 1996).
- To work effectively, price-cap regulation needs qualified management that is capable to exploit the benefits of price-cap regulation. Implementation of a price-cap regulation should therefore be linked with industry and company restructuring.

Hybrid regulation regimes have become more common (i.e., under a price-cap regime a large number of cost components are allowed automatic pass-through into tariff adjustments). In practice, the number of adjustments is usually limited (for example, once per year) and/or the tariff may only be adjusted if input price increases exceed a preset ceiling.

Conclusions. In practical applications, RoR and price-cap regulation approaches tend to converge: Initial prices tend to be cost-based under price-cap regulation and many RoR regimes use price adjustment clauses (see Estache/Guasch/Trujillo 2003). The ability of balancing the provision of incentives to improve efficiency and to reduce costs, financing requirements and eventual sharing of benefits with consumers makes *(hybrid) price-cap regulation* the preferred approach.

Although the information requirements seem to be too complex for immediate application in a large welfare-based DH industry like in China, hybrid price-cap regulation could be the *preferred approach in the midterm*. The initial prices would be cost-based with profits based on the value of

[28] Actually, the boundary between both price setting approaches is fuzzy. Even a cost-based regulation allows retaining profits due to cost savings realized in the short period between tariff approvals.

[29] For a discussion of the *X* factor, see, for example, Olson/Richards 2003.

assets, and they would be adjusted over time according to an adjustment formula. Typically, the use of the *X* factor reflecting the expected productivity increase in the sector reduces the potential extra profits due to cost savings. Taking into account the large undercapitalization of the Chinese heating industry on the one hand and high investment requirements on the other hand, setting the *X* factor at zero could support the financial recovery of the sector. It should, however, be ensured that these profits are invested into the rehabilitation, modernization, or expansion of the heating systems. The introduction of efficiency improvement targets for producers could be introduced, similar to the regulation for the English and Welsh water sector.

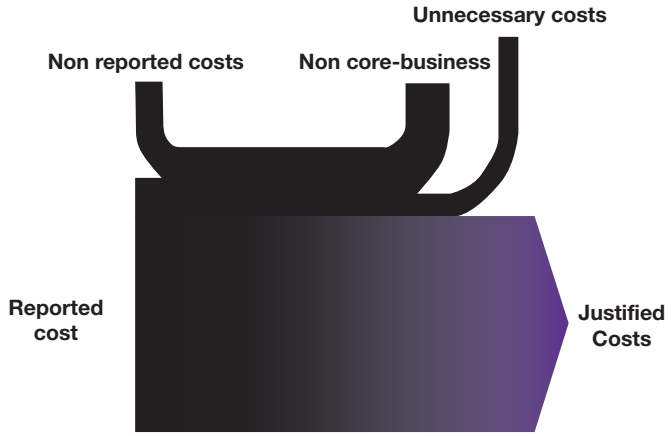
During a transition period, a cost-based approach to setting heat tariffs is more practical for the reasons outlined on page 42. It can build on existing information and procedures, improve on them, and put into place new information requirements and procedures. The government/regulator might also consider establishing different pricing principles for private and public heating companies. This was done, for example, in Lithuania to promote private-sector participation in the heating sector. There, the privately owned DH company will benefit from a longer approval period of five years with a price cap, compared to three years for public DH companies. Similarly, public DH companies could be regulated under RoR and private DH companies could get a price cap.

Practical Issues I: Defining and Determining Costs

Regardless of the pricing principle applied in practice, the starting point for the design of heat tariffs is an analysis of the costs of providing the service. The first question to resolve is, which costs should form the basis for determining the heat price—actual reported (accounting) costs, justified costs, standard costs, benchmark costs, or future costs?

There is general agreement that all costs that can reasonably be attributed to heat supply should form the basis for heat tariff calculation. In Eastern Europe, relevant costs are usually those that are justified or indispensable, relating to the core heating business. As Figure 2.2 shows, some nonreported costs may have to be added to reported costs, for example, depreciation of investments contributed by others. Costs of noncore business or costs considered unnecessary should be deducted, for example, operation of recreation centers or very expensive cars. The cost basis and cost accounting rules for heating enterprises should

Figure 2.2 Procedure for Determining the Justified Costs



Source: Authors.

be well defined, so that heating enterprises can easily use their accounting costs as input for the calculation of heat tariffs.

Accounting costs, however, are past costs, while heat tariffs should cover the costs to be incurred in the coming heating period(s). The use of *future costs* requires forecasting of demand and costs related to this demand. Ideally, those forecasts would be combined with the business plan of the heat enterprise that describes physical and financial flows during the next heating seasons. As costs cannot be predicted with a reasonable precision over a longer period, tariffs should be based on a forecast covering three to five years. During this period prices should be allowed to be adjusted to inflation or changes in input prices (see page 82). When price adjustment formulas are used, there is no need to predict future input prices. The current or known input prices can be inserted in the price adjustment formula to easily adjust the tariffs to changing input prices.

As explained earlier, Chinese heat supply enterprises use different methods to report their expenses, according to the requirements of their legal and ownership status. Until all heating companies actually apply the uniform accounting standards that are in force for business enterprises and SOEs (see page 44), it will be extremely difficult to compare the costs of different kinds of heating companies. Within the ESMAP project, the teams in the four pilot cities therefore used an approach whereby total heat supply costs are determined as *standard* costs instead of accounting costs. The methodology pioneered by the Tianjin Working Group may serve as an example (see Box 2.3):

- Fuel, electricity, and water costs are determined according to norms and actual operational experiences (see item 5 in Box 2.3).
- Depreciation is calculated based on typical investment costs[30] (on which construction charges in Tianjin are based; see Box 2.7) and lifetime of major equipment.
- The other costs are weighted average costs of the five DH companies that had been chosen as examples for cost investigation and tariff determination.
- Financial costs are excluded from consideration,[31] because they are either very low or loans to finance investment costs are offset by construction charges (connection fees).
- Standard costs are related to the supplied floor area (in yuan per m²), since hardly any metered data on heat produced or consumed are available. Of particular importance is the assumption of normative average heat demand of typical buildings (see item 4 in Box 2.3).

The standard costs are the cost basis for determining the tariffs. In the four cities the standard costs have been computed as average costs over the past one to three years, assuming that they would be representative for all heat suppliers in the respective city.

Taxes and profits are added to determine the final tariffs, which are expressed in terms of yuan/m²:

$$p = c * (1 + r) * (1 + t)$$

where

p heat tariff [yuan/m²]
c standard costs [yuan/m²]
r profit rate [percent]
t tax rate [percent]

The main reason for selecting the standard cost approach was the lacking uniform accounting system, which made serious comparisons of the costs of the various companies difficult, if not impossible.

Standard costs are not benchmarks that should be achieved by the heat suppliers through

[30] In Harbin the same approach is applied. In Changchun, the normal value of depreciation set at 6 percent of fixed assets and standard lifetime of equipment is used. In Taiyuan the depreciation rate of 6.76 percent is applied to the investment in heat supply actually completed in the relevant year.

[31] In Harbin, financial expenditures are not accounted for separately. In Changchun, they are lumped together with taxes. Only in Taiyuan do they constitute a separate component.

improving the efficiency and performance, but rather, are typical or "state of art" costs, and they mix actual and *normative* costs. Standard costs should also not be confused with justified costs, as they do not take into account the specific characteristics of an individual heat supply company. For example, heating companies with gas-fired boilers have higher fuel costs due to high gas prices. If such boilers are used for environmental reasons, their costs should be considered justified. Under Tianjin's standard cost approach, however, these differences were neglected. Taiyuan, Harbin and Changchun made allowances for different generation technologies, defining, for example, separate categories of heat tariffs for CHP- and HOB-based centralized heat.

The local experts of the participating cities advocate uniform tariffs for the whole city. A major reason to determine uniform tariffs instead of individual tariffs for each company is the large number of heat suppliers, which makes the individual determination of company-specific tariffs based on the justified supply costs of each company arduous and difficult (see page 63 for details).

Although this approach of calculating a uniform tariff based on standard costs has many drawbacks, it is an important step forward, as it is an approach to make the real costs of heat supply visible and to decouple the determination of heat tariffs from political deliberations. This approach should, however, only be viewed as a transitory measure, since it does not result in a transparent pricing system with good incentive properties. Among the shortcomings are the following:

- The standard cost approach cannot replace the need for the uniform application of an appropriate accounting system for all heat supply companies.
- The standard cost approach is based on historical costs, not projected costs, and is thus not forward looking. Worse, in some applications, the calculation of standard costs was based on averaging cost data of several years back.
- Taxes are added regardless of the actual tax obligation of the individual company.
- Profits are linked with costs, providing an incentive to inflate costs. The main reason for not linking profits with the assets, and thereby investments, is that assets of heating companies are not properly inventoried and valued. The working groups did not consider determining them as standard values as an option.
- Companies with production costs below the standard costs will get extra (windfall) profits. This would be justified if only companies with a good performance would benefit from these extra profits. The methodology does not, however, allow distinguishing between profits/losses due to good/bad performance of the company (internal reasons) and profits/losses due to favorable/unfavorable conditions (external reasons). For example, in Tianjin, the two companies with very high supply costs above the standard costs were (i) a small supplier with a gas-based HOB and (ii) a large DH company using cogenerated heat with high depreciation and repair costs and a low heat density. The latter is the only company among the five that is liable to pay VAT. Thus, the losses seem to be triggered by a mix of internal and external reasons. It could be considered to use extra profits exclusively for rehabilitation, modernization, and expansion investments or for funding of social assistance programs.
- A uniform tariff was also justified with the fact that heat is not yet accepted as a commodity, but continues to be considered as a welfare service. However, in most markets Chinese consumers are aware of different prices of commodities and accept such a situation.
- As explained earlier, Chinese heat supply enterprises use different methods to report their expenses. Thus the determination of standard prices is highly subjective and relies on the knowledge and expertise of experts.

Recommendations. Tariffs should be closely and directly related to costs. Moreover, since tariffs are related to future sales and, correspondingly, future costs, they have to be based on projected costs rather than on past (historical) costs.

Box 2.3 Tianjin Methodology to Determine Two-Part Tariffs

1. Select several typical heat supply companies, covering at least x% of total centralized heat supply (or supply area) of the city

↓

2. Document individual supply costs and their components for each DH company (in RMB/m²)

↓

3. Experts determine reasonable averages for each cost component; company individual costs are adjusted accordingly

↓

4. Determine heat consumption indicators of residential and non-residential consumers

residential building: 34W/m², public building: 44W/m²

↓

5. Experts determine standard for each cost component, by adjusting unreasonable factors and considering practical heat supply operations

Depreciation: Based on investment cost (construction charges) and standard life time of main equipment

	Items	Unit	Standards	
1	Fuel consumption	kg／m²	25	Variable Costs
2	Water consumption	kg／m²	55	
3	Power consumption	kWh／m²	3	
4	Employees	1 employee/ 10,000m²	Permanent: 0.57 Part-time: 0.9	Fixed Costs
5	Depreciation cost	RMB／m²	3.96	
6	Maintenance cost	RMB／m²	1.12	
7	Overhead cost	RMB／m²	0.58	
8	Other costs	RMB／m²	0.32	

Note: financial costs are omitted since they are very small or offset by construction charges (Box 2.6)

↓

6. By applying current unit price for variable inputs and employees, standard heat supply costs are calculated

	Items	Symbol	Unit	Ratio
1	Fuel cost	C_r	RMB／m²	7.5
2	Electricity cost	C_d	RMB／m²	1.8
3	Water cost	C_s	RMB／m²	0.29
4	Salaries and welfare cost	C_z	RMB／m²	1.61
5	Depreciation cost	C_j	RMB／m²	3.96
6	Maintenance cost	C_w	RMB／m²	1.12
7	Overhead cost	C_g	RMB／m²	0.58
8	Other costs	C_t	RMB／m²	0.32
9	Heating supply cost	C_q	RMB／m²	17.18

↓

7. Calculate heat supply cost per unit of heat consumption:

residential: (17.18/0.034*24 hours*140 days)= 0.1504 RMB/kWh

↓

8. Determine reasonable profit level as percent of heat supply cost

residential: 2%, non-residential: 8%

↓

9. Tax calculation: sales tax minus net purchase taxes plus urban construction and education taxes

about 6% of heat supply costs

↓

10. Heat price calculation: unit price = net supply cost plus profit ratio plus tax ratio

residential: 0.1626 RMB/kWh
non-residential: 0.1722 RMB/kWh

↓

11. Calculate tariff for non-metered area

residential heat consumption is 114.24kWh/m², resulting in heat price of 18.575 RMB/m²
non-residential heat consumption is 147.84kWh/m², resulting in heat price of 25.458RMB/m²

↓

12. Calculate tariff for metered area: two-part tariff

proportion of fixed charge=50%=proportion of variable charge
Fixed part of heat tariff (residential): 0.1626*0.5*0.034*(24*140)* [m² of construction area]
Variable heat tariff (residential): 0.1626*0.5* [heat consumption, kWh]
Annual Heat Bill = 9.288 * [m² of construction area] + 0.0813 * [heat consumption kWh/y]

Source: Tianjin Experts Team 2003.

Implementing this approach requires the general application of uniform accounting standards and financial forecasts for the next few heating seasons. Such financial forecasts are particularly relevant for heat supply systems that are expanding rapidly. Chinese experts suggest that the existing uniform accounting standards for business enterprises should be adapted for use by heating companies, independent of their legal status. The application of these standards should be mandatory for all heat supply companies. Simplified standards could be established for very small heat supply companies (e.g., with a connected load below 5 MW).

Transition period. Until uniform accounting rules for heating enterprises are established, an approach based on standard costs may be preferable to the current practice. Care has to be taken, however, to determine standard costs in a more transparent way that does not provide windfall profits for some companies and punishes others unjustifiably. If the cost structures of heat supply companies are different, say due to different heat generation technologies, different tariffs should be considered. Examples are heat from CHP plants versus HOBs or gas-based heat versus coal-based heat for which many cities are already using different tariffs (see page 43).

Practical Issues II: Cost Structure and Cost Distribution

After the relevant costs of heating have been determined, the next step in the process of tariff setting is to distinguish different types of costs that will have a bearing on the structure of the tariff. As mentioned on page 44, centralized heating is a network service with a substantial share of fixed costs that do not vary with sales. With the transition from area-dependent tariffs to tariffs that depend on consumption, it will be necessary to distinguish between fixed costs that do not vary with consumption and variable costs that do. In the simplest manner, fuel, water, and electricity consumption are assigned to variable costs, while all other costs are considered fixed costs. The cost data can be taken directly from existing accounting information, but this method is not precise. A more reliable basis for cost projections and tariff setting where the energy and capacity charges of a two-part tariff are directly linked with both cost components should consider the real cost dependencies.

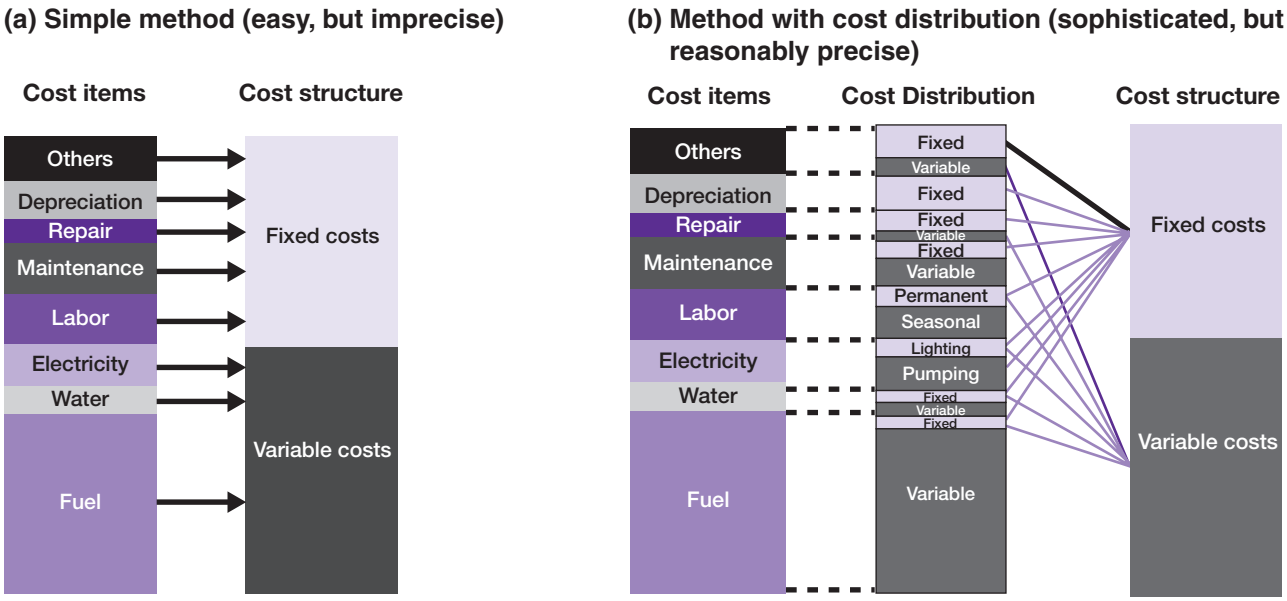
The costs incurred by a heating company should also be allocated to various cost centers and to products and services that are provided. Cost allocation serves to allocate the various cost types to the various products or services (i.e., hot water for space heating and domestic hot water, and steam). In addition, it allows allocating the costs to a number of cost centers along the value chain (i.e., generation, transmission, distribution, substations, sales, and overhead).

Fixed costs are costs that remain constant regardless of the sales volume during the defined planning period. They include interest expenses, rent, depreciation, insurance, and salaries of the permanent staff. The determination of the fixed costs depends obviously on the length of the defined period, as in reality no costs are purely fixed. However, this distinction serves the purpose of cost accounting for a limited planning period. *Variable costs* change directly with the level of production and sales. They include, for example, fuels, direct materials, and labor linked with the level of production. In most cases, it is easy to determine whether costs are variable or fixed. For example, the biggest cost item, fuel, is a variable cost. With other inputs it is more complicated. For example, water and electricity consumption are partially linked with sales, partially independent of sales.

The distinction between fixed and variable costs helps to prepare more reliable costs forecasts, as it allows to determine whether and to what extent certain costs will vary with changes in outputs. The more precisely such cost distribution is carried out, the more reliable the projections will be. Accordingly, costs should be analyzed as carefully as possible, but with reasonable efforts and costs (see Figure 2.3).

Cost allocation would be easy if all costs could be unambiguously assigned to a specific product or cost center (i.e., if all costs were direct costs). However, if inputs are used for various processes or products, their costs are common costs. For example, electricity can only be unambiguously assigned to the respective cost centers if these are equipped with separate

Figure 2.3 Cost Structure Based on Cost Distribution



Source: Authors.

electricity meters. Otherwise, criteria or cost distribution keys have to be defined on the basis of which the costs can be distributed. For example, the electricity used by the network pumps can be estimated based on the pump capacity and hours of operation.

Cost distribution may seem to be too sophisticated in the early stage of heat tariff reform, as the calculation of tariffs as described above does not require this. A reasonable decomposition of costs by cost centers has, however, various advantages. It provides a useful management tool to improve efficiency and performance of the heating company by facilitating the identification of inefficiencies and cost drivers in the company. Intercompany comparisons will be more effective, as not only the total production costs can be compared, but also the costs of the individual cost centers. If tariffs have to be differentiated based on the scope of services, identifying the respective costs will be easy. For example, in Taiyuan some customers are owners of substations, while heat-supply companies own other substations. The tariff for the first group is reduced by the costs related to substations.

Taxes

DH companies are almost universally taxed on their net income. This does, however, not constitute a cost. In addition DH is generally subject to three other kinds of taxes: Value-added tax (VAT), special fuel excise taxes or energy taxes and environmental taxes. Consumers of DH services have to pay VAT in most countries (see Table 2.3). Reduced VAT rates for residential heat customers were common in Eastern Europe, easing somewhat the transition to full cost-recovery tariffs.[32]

In China, the most important tax on heat is the value-added tax (VAT). Under the current regime, some enterprises (particularly heat and power companies) have to pay VAT, while others do not have to pay, depending on the legal status. Other, smaller taxes such as urban construction and education taxes can be applied, but this also

[32] See Meyer (2003). Based on a 2006 EU directive, reduced VAT rates can be applied to district heating until the end of 2010; see http://ue.eu.int/ueDocs/cms_Data/docs/pressData/en/misc/88237.pdf. Such reduced VAT rates have been applicable for gas and electricity for several years. The EU directive has thus created a level playing field between several competing heat supply technologies.

Table 2.3 International Comparison of VAT and Other Taxes for DH and Other Fuels, 2003

Country	VAT Level	Type of Taxes
Austria	20 percent	Energy taxes are applied and used for CHP/ DH support measures
Bulgaria	20 percent	n.a
Croatia	22 percent	n.a
Czech Republic	5 percent for DH will be kept until 2007* 22 percent for other energy sectors	Taxes on fuels used for heating will be introduced from 2007
Denmark	25 percent	No exception for DH sector
Estonia	5 percent for DH 18 percent for other energy sectors	Exemption and afterwards taxation reduction on shale oil used for DH until 2013
Finland	22 percent	Energy taxes used to promote DH
Germany	16 percent	Fuel taxes and electricity taxes; exemption or reduction of taxes on certain fuels are used for CHP units
Hungary	15 percent for DH and NG 25 percent for electricity	Energy and environmental taxes started to be introduced but can be claimed back for CHP and DH; transitional period up to 2010 for taxation on electricity, NG and coal for DH
Iceland	14 percent 24.5 percent for other products	No other taxes for DH sector
Italy	DH: 10 percent for residential and 20 percent for other customers	n.a
Korea	10 percent	Fuel taxes
Latvia	Under discussion	Excise tax on heavy fuel oil for DH but with transitional period up to 2010
Lithuania	DH : 5 percent for households (18 percent and 13 percent compensation) 18 percent for other energy sectors	Exemption for coal, coke, lignite and NG until 2010
Netherlands	19 percent	Fuel taxes, environmental taxes, excise duties
Poland	22 percent	Excise tax on oil and liquefied gas for DH, transitional period for coal used for DH until 2010 and until 2014 for NG under certain conditions
Romania	16 percent	n.a.
Slovakia	19 percent	Transitional period until 2010 for electricity and NG taxation
Sweden	25 percent	Excise duties on fuels, energy taxes and carbon taxes are applied and used for the promotion of CHP/DH

Source: Euroheat&Power "District Heat in Europe—2005 Survey".

**Note:* See footnote 32. NG: natural gas.

depends on the legal status. The average tax rates on heat included in the heat tariff as reported by the participating cities vary widely:

	Tianjin	Changchun	Harbin	Taiyuan
Average tax rate	6 percent	13 percent	6 percent	9 percent

For calculating the new tariffs, all city reports assumed that VAT and income tax have to be paid by all companies. Several cities propose—at least for a transition period—an exemption from VAT and a reduction of the income tax. Although a tax exemption would mitigate the impact of other cost increases and possible tariff increases, all customers would benefit from the tax exemption regardless of their financial situation. Tax exemption is a specific form of subsidy that generates price distortions, particularly if alternative heating systems do not benefit in the same way.

Recommendations. Applicable tax rates should be the same for all heat supply enterprises, regardless of their legal status. This is particularly important when uniform heat tariffs are applied for all heating companies in a municipality. For a transition period, tax exemption or a lower VAT rate for residential customers could help to cushion the effect of increasing heat bills, but this would benefit all customers regardless of their income level. If fiscal measures in support of centralized heating were considered, it would be preferable to choose them in a way that advances heat reform—for example, by introducing reduced tax rates for meters, control equipment, and other energy-efficient equipment.

Profits

Tariffs currently do not explicitly comprise a profit component. Under the current tariff system, a heating company would generate profits if its revenues exceed its expenses.

The national experts emphasize the importance of a profit margin to be included as a tariff component to attract private capital and accumulate equity capital. The profit rate should be related to fixed assets and working capital, with the possible exception of the capital that represents the connection fees. A cost-based profit is accepted as a transitional measure (but see *Transition* section below). The level of the profit rate would be limited by the commercial bank interest rates for savings (about 2 percent) and interest rates for loans (up to 8 percent). Another indicator for setting profit rates in the heating industry would be investment profit rates in other industries, which are, on average, 6 to 7 percent.

The city working groups chose to base profit on total costs (see page 31). The profit rate for residential consumers would be set at a lower level than for nonresidential consumers, according to the pricing principle of *"break-even with meager profit,"* referred to in the heat reform guidelines:

	Tianjin	Changchun	Harbin	Taiyuan
Profit rate residential consumers, percent	2	3	2	5
Profit rate nonresidential consumers, percent	8	3	6–8	15

A cost-based profit rate ignores the fundamental difference between (running) costs and capital. If the profit should be related to costs, it would be more reasonable to compare it with the operating margin or return on sales of other industries. The biggest drawback of relating profits to costs is the danger of creating incentives to inflate costs in order to increase profits. Defining different profit rates for residential and nonresidential consumers as proposed by the local working groups does not have an economic rationale; it is a relic of the old welfare system.

Recommendations. Heat tariffs should include a fair profit. Otherwise it would be difficult to attract investors to this sector. In many countries, profits of DH companies depend on costs, even though it is almost universally acknowledged that this provides incentives to increase costs, while the opposite should be achieved. With cost-based profits, regulators assume the task of controlling costs. Experience shows, however, that they have not been very successful in the burdensome and costly task of controlling of the costs of utilities.

Coupling the profits with capital (e.g., value of assets and working capital) instead would contribute to stimulating investments targeted at the rehabilitation and possibly the expansion of the heating systems. There is a chance that this might create incentives for overinvestments. In some instances, investments are controlled by regulators; for example, in Lithuania the regulatory agency and the regulated company have to agree on an investment plan with targets for efficiency improvements.

Transition. Profit margins should be related to capital as soon as possible. If inventories of assets do not exist, they could be estimated using standard values similar to the approach applied to define standard costs. In this way, the incentive to increase costs would be eliminated without impacting the profit. The estimated asset values should be replaced by the real values as soon as possible. Enterprises should be obliged to inventory and revalue assets within a certain period. In parallel with changing to asset-related profit margins, profit rates for all customer groups should be equalized as soon as possible at a rate that is commensurate with attracting investors.

Cost-Reflective Pricing: Two-Part Heat Tariffs

Traditionally, heat was not metered in DH systems under central planning, and customers were billed according to area (m^2) or volume (m^3). In general, this is still the case in China. The definition of area varies between cities—it can be construction area, living area, heated area, and so on—which makes tariff comparisons very challenging.

When metering is introduced, a heat tariff that accommodates metering is usually structured like tariffs of other network-based energies, such as electricity and natural gas. The provision of network-based energy requires the build-up of an elaborate infrastructure, resulting in fixed costs in addition to the variable costs, which depend on the amount of energy actually produced and consumed. Two-part tariffs reflect this cost structure and thus consist of a fixed or capacity component (yuan/m^2 or yuan/MW) and an energy component (yuan/MWh). They are able to provide incentives to suppliers and consumers to use resources efficiently. See Figure 2.4 for an illustration.

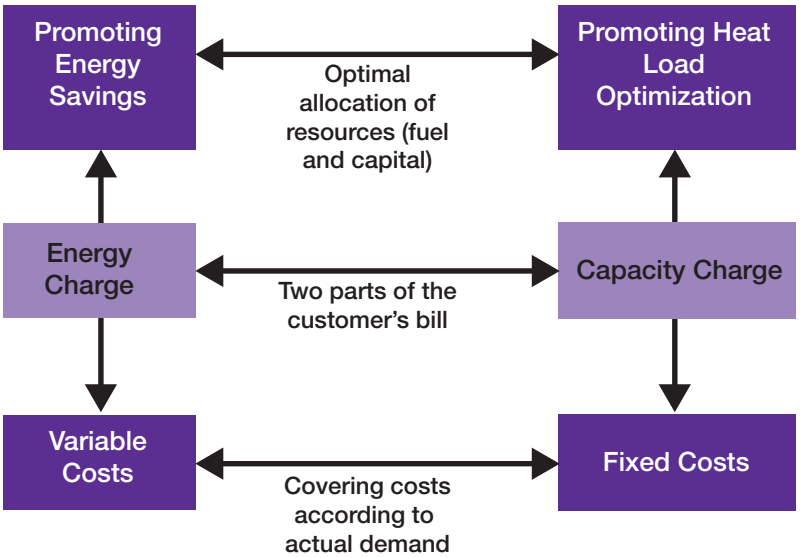
The energy charge (covering variable costs) allocates resources (mostly fuel) efficiently by adjusting the supply to the actual demand of consumers. Similarly, the fixed charge (mostly covering capital or related costs) will help to allocate capital and other fixed factors efficiently. When the fixed charge is based on the customer's installed capacity (MW), the customer has an incentive to size the capacity correctly or even to invest in energy-saving measures to reduce capacity and thus decrease the heating bill. Such a reduction in existing customers' demand allows the heat supply company to use the released capacity to supply new customers, without having to invest in new heat-generation facilities and (partially) other components.[33]

Most Western European DH companies use such a two-part tariff, since it eliminates the volume risk resulting from fluctuations in heat demand. These can be very substantial even for a given temperature level, as shown in Figure 2.5 for a typical modern DH system. In the typically capital-intensive CHP-based DH systems in Western Europe, the share of fixed costs is rather high, about 70 percent. However, to provide more incentives for heat consumers to save energy, DH tariffs tend to have a rather low share of the fixed component (20 percent in Denmark, 30 percent in many other countries).[34]

[33] In practical applications, two-part tariff systems differ from the "ideal two-part tariffs" discussed on page 46. The practical two-part tariff components are calculated as an average of the variable costs (not as incremental or marginal production costs) and of the fixed costs, respectively. A "true" marginal cost pricing approach would define the marginal costs as the production costs of the last unit (i.e., the marginal costs of this company). This is the cost of peak production, which is usually extremely expensive. This would likely result in unacceptably high tariffs. If in contrast the average short-term costs (i.e., the variable costs) are applied, the tariff would not cover the fixed costs. The marginal cost approach could be applied to differentiate tariffs based on the time of use (such as in the electricity sector with night time and daytime tariffs).

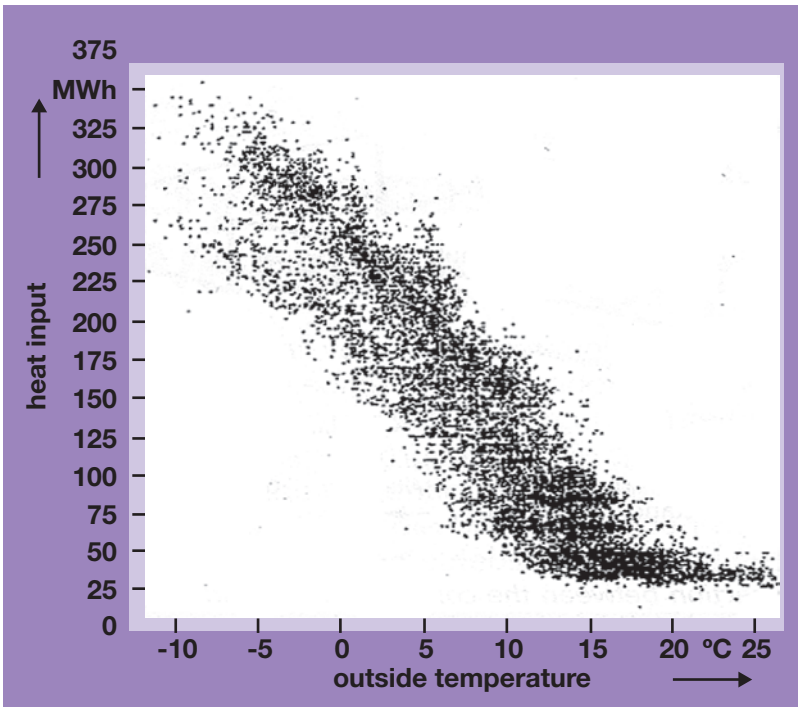
[34] The EU SAVE directive and the national implementation norms specify that for consumption-based billing only 30 to 50 percent of total heating costs can be allocated independently of metered consumption (JP/CEEB 2002).

Figure 2.4 Roles and Functions of the Two Tariff Components



Source: Authors.

Figure 2.5 Demand Variation of a Typical DH System



Source: Stadtwerke Flensburg.

This approach is feasible in most Western European countries, as the volume risk is much lower than in Eastern Europe, since most of the energy saving potential on the demand side is already exploited and industrial demand has stabilized.

In Poland, for example, the fixed costs of DH supply are usually closer to 60 percent. The initial regulations for the DH sector, however, did not allow companies to recover any fixed costs above 30 percent or to recover them instead as part of the variable tariff component. A more recent ordinance defines heat losses and that part of fixed costs exceeding the 30 percent limit as justified variable costs (ESMAP 2001).

In addition to fixed and variable components, other tariff elements such as charges for water or condensate losses (charged as $/m^3) are quite common. In Denmark, but also in cities in other countries, DH companies encourage consumers to lower return temperatures, which would allow more efficient operation of CHP plants; they offer up to 10 percent payback for return temperatures below average and require an additional payment of 10 percent for return temperatures above average. As a result, within a few years, return temperatures dropped 10 to 15ºC (from previously above 65ºC; DBDH 2/1999). In South Korea, nonresidential customers are subject to time of use charges (JP/CEEB 2002).

In several countries in Eastern Europe, *one-part heat tariffs with only an energy component* are applied for residential customers. The reasons are twofold. Consumers would have more incentives to invest in measures to reduce their heat consumption and thus their heat bills if they were faced with a *one-part heat tariff*, resulting in a faster payback of energy-saving investments. An additional reason to promote a one-part tariff was the increasing incidence of DH customers disconnecting from the DH networks in the mid- to late 1990s, especially where competition from other fuels was fierce and/or affordability problematic.[35] For DH companies a one-part, energy-only heat tariff would lead to a more variable revenue stream and a reduction in sales that would not be compensated by an equivalent cost decrease. Bankruptcy would be unavoidable, unless the supplier could drastically reduce capacity, connect new customers or seek and obtain a tariff increase.

The Chinese experts decided that two-part tariffs would be the most appropriate choice for the heating sector in China. All city reports start with calculating fully cost-covering lump-sum tariffs. Table 2.4 compares the old and the new lump-sum tariffs for residential and nonresidential customers. Two-part tariffs are derived from those lump-sum tariffs by using the normative figures for heat load (W/m^2) and heat energy (kWh/m^2, yr). In principle, one component covers the fixed costs (capacity charge) and the other variable costs (energy charge).

The fixed part of the tariff will, for the time being, depend on area, since real heat loads of customers are unknown. Thus, the heating sector is forgoing one important potential benefit of the two-part tariff. It is highly likely that the installed capacity of substations in existing heating systems is oversized (in terms of real heat demand and not of theoretical heat demand). With a capacity-related fixed charge, customers would have an incentive to reduce capacity.[36] The released heat capacities could be used for the supply of new customers.

The shares of fixed costs in the four cities range from 44 to 56 percent of total costs (Tianjin, 44 percent; Changchun, 51 percent; Harbin, 55 percent; Taiyuan, 56 percent). The experts in all four cities propose to deviate somewhat from the actual cost structure and to allocate 50 percent of the costs to the energy charge and the other

[35] The three Baltic countries are examples, and even in the new German states some companies apply a one-part energy tariff for small customers (Meyer 2003).

[36] This could be achieved with investments that reduce capacity, such as building energy efficiency measures, as well as installing flow-limiters in the substation or on the flow-meters. The latter devices allow maximum permissible water flow levels to be set on flow-meters or regulators in the supply pipe. Once the desired maximum flow rate is set, the device prevents the water flow to rise above the contracted level.

Table 2.4 Heat Prices for Residential Consumers

	Tianjin	Changchun	Harbin	Taiyuan Direct/indirect
Original tariff (yuan/m²)*	15.40	23.50	31.15	3.3/3.8**
Calculated tariff based on standard costs (yuan /m²)	18.56	25.58	34.52	16.10/22.98
Two-part tariff energy charge (yuan /kWh)	0.813	0.983	Not calculated	0.066/0.086
Two-part tariff capacity charge (yuan /m²)	9.28	12.49	Not calculated	Not shown

Source: City reports.

* *Note:* The definition of m² changes from city to city.

** Monthly tariff—for heating period of 5 months tariffs would be 16.5/19 yuan/m².

50 percent to the fixed charge. The larger the deviations of the real consumption from the forecasted consumption, the larger could be the difference between real and forecasted revenues. If the variable tariff charge is higher than the actual share of variable costs, consumers will have a slightly higher incentive to save energy, and if they reduce heat consumption, this could result in losses for the heating companies since the revenue decrease is not fully compensated by a decrease of the variable costs.

Recommendations. A two-part tariff with an energy charge and a capacity charge will stimulate the rational use of energy two-fold:

- The energy charge will provide an incentive to consumers to save heat energy.
- The fixed charge based on capacity will provide an incentive to consumers to adjust the maximum heat load to their real needs.

Decoupling the tariff components from the actual cost structure would be risky in an economy where the behavior of consumers is widely unknown and not yet analyzed. Therefore, the tariff components should follow the real cost structure as closely as possible, at least as long as consumer behavior is not known and consequences for the heat supply company and consumers cannot be assessed properly. For new buildings, the fixed part of the two-part heating tariff should be based on heat load, and for existing buildings, efforts should be made to determine heat loads.[37]

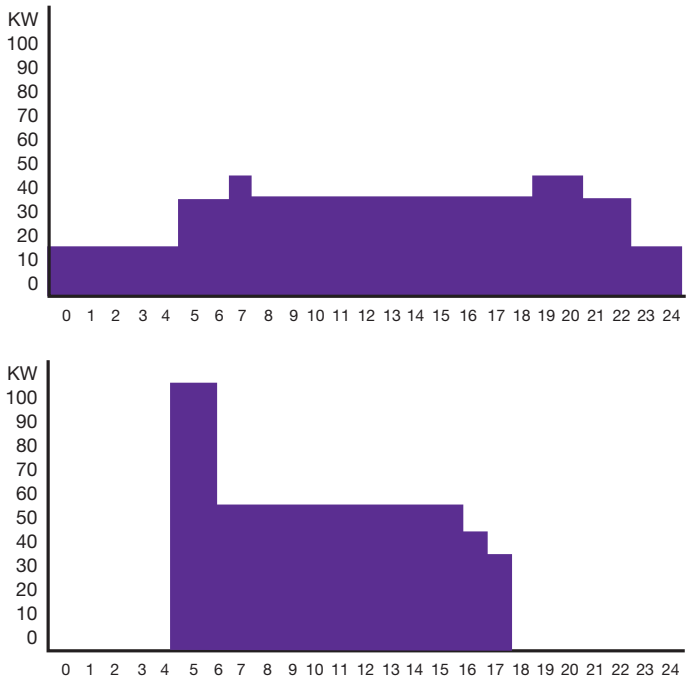
Tariff Setting—How Many Customer Groups?

A question that comes up frequently is whether all consumers should have the same tariff even if they have different consumption patterns. The underlying issue is that cost is affected not only by the total heat quantity consumed, but also by the structure of the heat demand (consumption pattern). Even if the total heat consumption is the same, it makes a big difference costwise whether heat consumption is uneven and, for example, short periods of sharp peaks are followed by a longer period of no or low consumption, or whether the heat consumption is even without distinctive peaks. In the first case, a larger portion of the total supply capacity is needed to satisfy the consumer needs than in the second case.

In case of lump-sum tariffs, differences in consumption are not taken into account and are thus not reflected in the heat bill. Consumers with different consumption patterns should therefore have different tariffs. But with a two-part tariff, different consumption levels (quantities) and different consumption patterns (even or uneven consumption over time) will result in different heating bills, even with the same tariff, provided

[37] Since it is not practical to determine heat loads of individual flats, each individual consumer would be assigned a share of the building heat load proportional to the flat size.

Figure 2.6 Load Curves for Different Consumption Patterns (hourly numbers)



Source: Authors.

the fixed part of the tariff is based on capacity (kW) rather than on area (m^2).

This cost-reflectiveness of the two-part tariff is illustrated in Figure 2.6, which shows the load curves of two consumers. It is assumed that they reflect the load of the day with the highest peak loads. Total heat consumption is the same for both consumers, and therefore the costs due to the energy charges are the same. However, consumer B has a much higher peak load. Assuming that he has contracted 100 kW, the part of his heating bill that is due to the capacity charge is much higher than for consumer A, who needs only 40 kW. Consequently, the average heating costs (in yuan/kWh) are higher for consumer B with the uneven consumption pattern.

In addition to different consumption patterns, the location of customers within the service territory of a heat supply company also has an impact on costs. For example, those customers who are close to the heat generation facility have lower distribution costs than more remote customers and the former cross-subsidize the latter if the heat tariff is the same for both. In network industries it is, however, common practice to disregard such location differences, since the complexity and cost of regulation would not be justified. In Poland, for example, the first version of the secondary heating sector legislation provided for a large number of customer groups and had to be revised since it proved to be too unwieldy; see Box 2.4.

Box 2.4 Poland—Extreme Tariff Differentiation Can Be Counterproductive

The secondary legislation implemented the objective of avoiding cross-subsidies in a way that resulted in extreme differentiation of costs and, thus, of tariffs. The total costs consist of heat generation costs, heat transmission costs and heat distribution costs. They all have to be calculated separately for each separate heat source and network, and a tariff is then calculated for each of the separate parts. Thus, the customers of one DH company can be exposed to quite different tariffs if they are connected to heat supply systems with different cost structures. Quite obviously, the complexity of this system does not result in transparent heat prices and is an administrative nightmare.

Source: ESMAP 2001.

In practice, only one customer group of *general* or *tariff* customers is usually defined, for which a *public* tariff is applicable. With special customers, which are either very big or have very special consumption patterns and/or time of use than average customers, supply companies conclude special contracts which could include a negotiated price taking into account these peculiarities.

Recommendation. For an integrated heating network, one tariff for all general or average customers can accommodate many different consumption patterns, if structured as a two-part tariff with energy and capacity charge.

Tariff Setting—Uniform versus Individual Tariffs

Currently, heat tariffs (lump sum tariffs) for all customers within one customer group are almost always uniform within a city, regardless of the individual cost structure of the heat supply enterprises. Exceptions are different tariffs for cogeneration-based and HOB-based heat in cities such as Shenyang and Changchun, for different fuel basis (like a much higher tariff for oil or gas-based centralized heating in Beijing), or for customers supplied by direct or indirect systems like in Taiyuan.

All cities involved in this project proposed to continue charging uniform tariffs for the whole city. Tariffs for different customer groups differ only by profit rates. A major reason to determine uniform tariffs instead of individual tariffs is the large number of heat suppliers (for example, about 230 in Tianjin), which would make the determination of individual tariffs and their supervision arduous, difficult and costly. Problems are exacerbated by the application of different accounting standards for different types of heating companies. In addition, it is argued that consumers would not understand and accept tariffs that differ, depending on which heat supplier is serving them.

The national experts favor company-specific tariffs, recognizing, however, the difficulties to implement such a system under the current circumstances. The main arguments against uniform tariffs are that they tend to hide inefficiencies and bad performance and do not provide the right incentives to reduce costs. To promote efficiency and performance improvements under a uniform tariff, regulation, and supervision would be required, which would, however, be quite costly. In contrast, individual tariffs reflecting the real costs of the companies would provide signals about good and bad performers.

Uniform tariffs produce (windfall) profits or losses for some companies, which are not the result of their performance. Uniform tariffs do not take into account reasonable and justified differences in costs. For example, in China suppliers using natural gas have higher production costs than those using coal. Heat supply companies operating in an area with a lower building density have higher costs due to the extended network than those operating in an area with a higher density. The application of several basic groups of heat supply companies, such as those listed above, should be considered during a transition period.

Recommendations. The proposed uniform tariff could be reasonable during a transition period, but a swift conversion to individual tariffs would be preferable and should be actively pursued through various measures. The development of an appropriate and uniform accounting system for all heat supply companies (and the enforcement of its use) was already mentioned. A system of equal tax treatment for all heat supply companies should also be established. The most important would be the consolidation of the heating sector, which should be supported by interconnecting heating networks in compliance with local heat plans and by merging heat supply companies.[38]

[38] Mergers could help to (i) reduce the costs of regulation and supervision of these enterprises, (ii) achieve economies of scale (mostly in terms of personnel costs and heat generation costs), (iii) create interconnected networks more suitable for cogeneration, and (iv) improve the efficiency and environmental performance of heat production. Uniform tariffs which could be applied for a transition period could promote such consolidation, as the owners of loss-making companies would have an incentive to merge them with profit-making ones. It is unlikely, though, that heat price reform alone could achieve consolidation. Separate measures are necessary, such as municipal heat supply development plans. Local governments will have to take an active stance in this process to ensure that consumers are not left out in the cold as a result of consolidation.

Consumers' awareness about heat becoming a commodity with varying costs should be increased through information and education campaigns. Expanding the use of heat metering, controls and consumption-based billing will give consumers the tools to determine their preferred comfort and thus consumption levels.

To accelerate the transition to company-specific tariffs, it should be considered to limit the use of uniform tariffs to a period of, say, 2 to 3 years. Afterwards, individual tariffs would be mandatory for larger heat supply companies. For small heat supply companies, uniform prices could continue to be applied for several more heating seasons. Publication of tariffs within and across cities by the regulatory or supervisory agencies could exercise an effective pressure on the management of companies with high tariffs to reduce costs and improve efficiency.

Stimulating Efficiency Improvements

The existing lump-sum tariff system offers no effective incentives to improve efficiency, neither on the supply side nor on the demand side. It is universally recognized that both parties need strong incentives to improve efficiency to reduce heating costs. The introduction of consumption-based billing with two-part tariffs for final consumers will be an effective tool to improve the efficiency of heat consumption (see page 39). It should be supplemented by other measures to save energy, such as effective implementation of building energy efficiency standards (see page 90) or financial support for poor consumers to improve building insulation (see page 10).

For the supply side the proposed tariff methodology based on standard costs with a cost-based profit provides few, if any, incentives to reduce heat supply costs. One could argue that those companies with costs above standard costs would try to reduce costs in order to reduce losses. But this may be wishful thinking if they continue to rely on support from municipal governments or lack the financial means or face political obstacles to effect change.

Based on the experience of pricing other infrastructure services such as electricity and water (see page 29), incentive-based pricing, such as price caps, provides some hope that suppliers will realize efficiency improvements. A baseline tariff is established based on the justified costs during the base period; it will be valid during a period of three to five years. A tariff-adjustment formula links tariff development over time with inflation development and expected productivity improvements. Companies that reduce their production costs during this period will realize higher profits. Only after the next tariff review would the tariff be reduced, in effect sharing the benefits of cost reduction and efficiency improvement with consumers. Box 2.5 shows the application of price caps in the DH industry in Lithuania and the Czech Republic.

In addition to pricing instruments, a variety of nontariff instruments are used to improve the efficiency of heat supply. A benchmarking system could assist managers in identifying the weak points of their respective heating systems. In some countries, such as in Lithuania, the regulator has the power to order regulated companies to achieve certain benchmarks or performance targets within a certain period of time. In China, municipal governments are experimenting with mandating heating companies to reduce inputs by a specified percentage. This is in response to the goal of the "11th Five-Year Plan" to reduce the energy intensity of the Chinese economy by 20 percent during the planning period. For example in Tianjin, annual fuel consumption should be lowered from 25kg/m^2 to 23kg/m^2.

One big obstacle to achieving efficiency improvements and cost reductions is the existence of norms and standards relating to the use of traditional centralized heating technologies, such as requirements for reserve capacities of boilers, minimum staffing of central substations, and so on. Modern automated technologies are very reliable, and the benefit of additional safety margins is very small compared to the costs. Norms and standards should therefore be updated to allow for the energy efficient and cost-saving application of modern technologies.

Ultimately, only in a commercialized heating sector with heating companies responsible for

Box 2.5 Price Caps in the District Heating Industry

In the DH industry, a form of price-cap regulation has been introduced only in Lithuania and in the Czech Republic. The formula applying to the Vilnius DH Company in Lithuania actually specifies a hybrid form of price regulation. The initial tariff is approved for a period of five years, and in addition to general inflation almost all cost drivers are indexed. Efficiency improvements that would reduce price increases are not included in the formula:

$$P_1 = P \times [0{,}416\,(G_1/G) + 0{,}06\,(M_1/M) + 0{,}018\,(K_1/K) + 0{,}096\,(V_1/V) + 0{,}169\,(S_1/S) + 0{,}241\,(1 + ir/100)]$$

where P = initial heat price
G = initial natural gas price
M = initial gas transport price
K = initial gas distribution price
V = initial cold water price
S = initial average salary
ir = official inflation rate

P_1 = new heat price
G_1 = new gas price
M_1 = new gas transport price
K_1 = new gas distribution price
V_1 = new cold water price
S_1 = new average salary

In the Czech Republic, the Energy Regulatory Office (ERO) regulates only CHP-based DH companies. The ERO announces periodical maximum allowable price increases (similar to the price cap approach) and can grant exemptions to the regulation formula. The heat prices are, however, not approved in advance by the ERO. Instead, the companies are audited by a separate agency to verify the correctness of the tariff. There are severe penalties for overcharging that seem to be effective in limiting price increases.

Source: Meyer 2003.

their financial performance and with a very clear regulatory framework, real incentives for efficiency improvements will be present. The experience in many cities in central and Eastern Europe—where heat supply is now as efficient as in Western Europe—is providing examples that this is not merely wishful thinking.

Heat Tariffs and Connection Costs

Investments in centralized heating infrastructure can be financed from different sources. Rehabilitation of existing infrastructure would be covered mostly by depreciation charges, which are included in the tariff. In China, however, depreciation is calculated based on average or standard costs of equipment and not on actual values such as original acquisition costs or current replacement costs. As discussed on page 41, assets need to be revalued, if necessary, to enable companies to calculate depreciation properly.

Different sources of financing should be considered for new or expansion of existing heating infrastructure. In Europe, loan financing is the most common source. In China, the preferred financing source for new heat supply facilities are connection fees paid upfront by real estate developers. See Box 2.6 with the example from Tianjin.

It is useful to distinguish between two different kinds of connection fees, as applied, for example, in various Western European countries (see Box 2.7), (a) charges for the direct connection of customers to a network and (b) other contributions to the DH system construction costs (investment costs):

a. The charges for building service connections cover only those equipment components particular to connecting a customer/building to a nearby network. Depending on the system architecture they would comprise connection pipes between the building and the network and perhaps a building substation. Such customer-specific equipment cannot be put to a different use if the customer disconnects and it should therefore be financed through a one-time

Box 2.6 Connection Fees in Tianjin and Other Cities

In Tianjin, connection fees are labeled construction charges. For new buildings, Tianjin municipality charges 92 yuan/m^2 for construction of heat supply facilities. This includes 57 yuan/m^2 for the heat source, 25 yuan/m^2 for the primary network and 10 yuan/m^2 for the central substation. The secondary network (from substation to building entrance) construction cost amounts to about 18Y/m^2, but this is normally directly handled by the real estate developer. In other cities connection fees based on construction costs are substantially lower—for example, in Harbin they amount to 68 yuan/m^2. In Taiyuan, connection fees cannot be charged.

Source: Tianjin Experts Team 2003, Harbin experts team 2005, Taiyuan Experts Team 2005.

payment by the customer who would become the legal owner. The heat supply company would have the right to operate and maintain the equipment for the duration of the contract.

b. The second type of connection fee is, in fact, a (partial) contribution to the construction costs of the heat infrastructure with each customer covering his share in the entire system cost, depending on the customer's connected load. As customers should not be overcharged by way of recovery of depreciation through tariffs on assets not owned and financed by the heating company, appropriate accounting and tariff calculation methods should be applied.

In China, there is an urgent need to clearly define the legal status of connection fees and apply appropriate accounting methods, since it seems that customers are currently overcharged in many cases by way of recovery of depreciation through tariffs on assets not owned and financed by the heating company.

If the heat supply company requires additional cost contributions from customers to finance equipment such as distribution network or heat generation facilities, they should be treated in one of the following ways:

Box 2.7 Connection Fees in Europe

In many Western European countries customers are charged two kinds of connection fees—provided the competitive situation allows this. The first covers the cost of connecting a building to the closest distribution pipe of the heating network. This is pretty straightforward, and the actual costs are charged. The second is a contribution to the costs of establishing the network and it is charged depending on the capacity of the customer's connection (see, for example, the General Conditions of DH supply in Germany, footnote 42). This does, however, not constitute any ownership in the DH system. The latter is an unusual practice if applied at all, since it could be an obstacle for promoting new connections. It is therefore avoided, at least as long as DH companies can arrange financing in a different way.

In *Poland*, a connection fee is applicable only for those parts of the heating system that are dedicated for the customer, such as a branch from the main network to the building. As per national regulation, the connection fee can be charged for only 25 percent of the cost; the rest is recovered in the tariff over about 10 years. In *Bulgaria*, the nationally uniform one-part tariff was replaced in 2002 with a two-part tariff. In addition, DH companies can now charge customers for the cost of connection.

Source: Authors.

- *Longer-term loan provided by the consumers.* Interest should be paid on the amount of customer contribution, at an agreed rate, which should normally not be less than the interest commercial banks would pay on long-term deposits. This amount is deducted from the customer's heat bill.
- *Equity contribution*. The consumer would become co-owner or shareholder and would participate in the profits.
- *The cost contribution is treated as a subsidy*. This reduces the original investment, costs and thereby depreciation charges and the tariff-rate base for calculation of return on assets.
- *Depreciation of assets is treated as a cost, but customer contributions to fixed assets are treated*

as a source of revenue. If tariffs are determined based on revenue requirements of the utility, this procedure will reduce the revenue required from tariffs and thus lower tariffs.

Although the last alternative may not be perfectly equitable in that all customers would benefit from the contributions not required universally, this procedure seems to be the norm among utilities. It has the advantage of being relatively simple from an accounting point of view. Regulators in network industries, using rate of return tariff regulation, tend to treat the connection fee as a customer deposit akin to the utility financing its investments through debt. Assets so created are considered utility assets and qualified for inclusion in the rate base.

As a more market-based alternative to charging connection fees, heating companies' access to bank financing should be improved. This could be achieved by clarifying asset ownership and a proper valuation of assets that would be serving as security for bank loans. Bank or capital market financing of heating infrastructure would also be supported by paving the way for private sector participation.

Recommendations. A sustainable heating system requires that the service is provided by a financially sound and effective enterprise. Therefore, heat supply companies need to have access to financial means to finance their activities, including operations and maintenance and system expansion. The most important source for heat system rehabilitation and expansion are depreciation charges, which should in principle be used to replace equipment that has reached the end of its service life, loans from commercial banks, and infusion of capital through private sector participation, for example, through the proposed franchise system.

Connection fees in the form of an up-front payment by the customer should cover those equipment components particular to connecting a customer/building to the network and where the equipment cannot be put to a different use if the customer disconnects. If the heat supply company requires additional cost contributions to finance other equipment such as distribution network or heat generation facilities, it should be ensured that the customer is not charged twice—that is, through a connection charge and through the heat tariff.

Conclusions

The Tianjin methodology for the determination of a two-part tariff has been applied for additional case studies in Changchun, Harbin, and Taiyuan and experts there accepted it for application. It has been broadly discussed and is recognized among national and municipal officials and other experts in the DH sector as an important step forward in heat pricing reform. It is the basis for the recently issued national heat pricing management method.

Applying this methodology is a first and important step to implement a more rational heat tariff system in northern Chinese cities.[39] However, the methodology needs to be developed further in order to support the realization of the heat reform objectives.

The tariffs are uniform across a municipality and are based on adjusted standard or average costs, rather than on the individual costs of a heat supply enterprise. Therefore, they cannot reflect cost differences in different heat supply enterprises due to the use of different fuels (gas being scarce and much more expensive than coal), different supply conditions, or differences in the management and performance of the heat supply enterprises. Until heating systems are more integrated into larger, more efficient systems and the number of heating companies is reduced from the hundreds to a more manageable number, the use of individual tariffs by heating company would be a task that the current supervising municipal authorities would not be able to handle. Additional requirements for the application of company-specific tariffs would be the application of uniform cost accounting standards and a uniform tax treatment of all

[39] The World Bank team agrees with the basic approach to heat price reform, but does not take responsibility for the specific results of the cities' case studies. The heating companies involved were not audited and the team did not undertake a financial analysis of the heating companies.

heating companies regardless of their ownership and legal status.

The proposed tariff methodology does not provide any incentives or obligations for the heat supply enterprises to improve efficiency and performance. Under the proposed methodology, tariffs are determined purely on a cost-plus basis. Profits are related to costs, thus providing an incentive to elevate costs. Relating the profit to the asset value or using a price-cap tariff system would improve incentives for efficiency, but the value of heating infrastructure assets is, at best, a very rough estimate. The use of competitive mechanisms to award concessions for heat supply areas, benchmarking of performance and enforcement of efficiency standards would be nontariff measures to improve efficiencies.

There is a consensus that a two-part heat tariff should be adopted. Provided the energy charge and the fixed charge are properly set, it can achieve a balance between financial security for the heat supply company, which will prefer to minimize unpredictable variations in revenue, and the need to provide strong incentives for efficient use of energy. A two-part tariff with a capacity charge based on contracted maximum demand would also provide proper signals to consumers about the costs of capacity. For the time being, it will, however, be related to the apartment area and thus not be able to provide the correct signals. Heat-supply companies should start to adopt heat load based capacity charges as soon as possible, particularly for new real estate developments.

Evaluating the results of heat metering is another important task to allow a better understanding of the actual heat demand and factors affecting the demand and designing an appropriate tariff base. Basing decisions about heat price structure and level on solid information will reduce the probability of misjudging reactions of consumers and suppliers of heat services and would thus prevent frequent adjustments in tariffs and other parameters.

Promotion of Heat Metering and Consumption-Based Billing

The introduction of consumption-based billing is essential in making heat a commodity and introducing market mechanisms in the heating industry. It requires that heat supply is metered, consumers can control their heat consumption, an appropriate tariff that depends on consumption is in place, the heating company is prepared or has contracted for processing metering data and issuing bills on this basis, and consumers have been informed and educated about the process of metering and billing, changes in payment terms, likely impact of metering on heating bills and possibilities to save energy.

The issues surrounding heat metering and consumption-based billing have been discussed in China for many years. The World Bank and MOC commissioned a team of Chinese and foreign experts between 2000 and 2002 to document the experience from heat metering in Europe and from demonstration projects in China, with the aim to analyze the factors affecting the choice of various heat metering schemes, review the lessons learned and make policy recommendations.[40]

Almost five years later, heat metering in China is still limited to mostly small demonstration projects in many cities and consumption-based billing was applied on a very limited basis in Tianjin (see Box 2.9). Within this project, the experiences gained and the continuing problems with heat metering and billing were reviewed and proposals to move forward were discussed. At least two important requirements mentioned above are now in place: Almost everywhere consumers are now responsible for payment of heating bills and appropriate heat tariffs, i.e., two-part tariffs, have been determined and are now applied in a large demonstration area in Tianjin. In addition, there seems to be a consensus to accelerate the introduction of a

[40] See JP/CEEB 2002.

minimum metering option at the substation or building level.

In the following, the main relevant conclusions of the 2002 report are summarized before new results, discussions, and conclusions are presented.

Options for Metering and Controlling Heat Consumption

There seems to be a strong preference in China for apartment-based heat meters, emulating the individual metering of electricity. Such heat meters can be installed in apartments with horizontal piping, such as in new and reconstructed buildings (i.e., buildings where vertical risers have been replaced with horizontal piping in apartments), but they are not suitable for apartments with vertical risers.[41]

Worldwide, apartment-level heat meters take a backseat to other metering options, building-level heat metering only, building-level metering with heat cost allocators at each radiator, and hot water flow meters. These four options (and various types of control equipment) were investigated in depth in the 2002 report with the following conclusions:

- Building level meters (option A), the dominant metering method in Finland and in many other European countries, is the least costly of the four and is simple technically and for billing arrangements. Since each apartment is billed according to its floor area, Option A may generate little incentive for individual households to save energy, although the building owner or management company may have a direct interest in energy conservation. It is argued that for well insulated buildings with well balanced heat distribution, such as the case of many Finnish buildings, Option A could be the most cost-effective metering method. A different, highly relevant aspect for China is that Option A provides an easy step for many of the existing buildings and heating systems to switch to heat metering and consumption-based billing at the building level, a minimum requirement for heat commodification, without encountering the significant additional hardware and software costs and billing complications which the other metering options entail.
- To accomplish individual heat metering, adoption of the other options will be necessary. Heat cost allocators (option B), widely used in Germany, Denmark, Austria, Switzerland, Poland, Bulgaria and other Eastern European countries, have the advantage of achieving most if not all of the benefits of individual heat metering at a modest metering cost. However, the application of Option B also requires extensive knowledge of radiator specifications, special skills for billing (heat cost allocation) and annual replacement of devices if evaporative allocators are used. The newer electronic heat cost allocators are more user friendly and can be equipped to be read remotely, thus accelerating and facilitating billing (see Box 2.11). Heat flow meters (option C), adopted in South Korea, simplify the heat cost allocation with the application of one hot water meter per apartment, and the billing is based on simple arithmetic calculations without the use of special techniques. Finally, apartment-level heat meters (option D), although the most expensive of the options and therefore only rarely used internationally, provide a direct heat consumption reading for each apartment, and are the simplest and most transparent set up for billing. The apartment-level heat meter can serve to allocate heat expenses to an individual apartment (as in option B), but more often it is used for direct billing based on the heat supply contract. In South Korea, problems with unreliable individual heat meters and bad water quality forced a switch from option D to option C.
- Although all four metering options enable consumers to be billed according to their

[41] See the Annex for an explanation and for schemes of horizontal and vertical piping.

consumption, the degree of precision, and simplicity in determining what the heat consumption is for one apartment varies for the different metering options. The costs and benefits of heat metering and billing are critical factors affecting the choice of a certain option. Based on experiences from Western and Eastern Europe, consumption-based billing of whole buildings can save 5 to 10 percent of the heat supply, mostly due to improved control and regulation. Adding flat-wise consumption-based billing could generate another 15 to 20 percent of savings. At least for the lower cost metering options, those energy savings could make up for some or all of the additional cost within a reasonable period of time.

- There is no heat metering technology that is clearly preferable to all others. Apartment-based heat meters tend to be more reliable and accurate than heat allocation meters, but there is no evidence that their much higher costs are compensated by higher benefits. Thus, a "one size fits all" approach in heat metering should be avoided. Least-cost solutions for metering should be identified for both building types (i.e., energy-efficient and other buildings). The solutions will not necessarily be the same for both types; different technologies could be applied.

In systems with bigger substations, as in China, it would be preferable to meter the heat supply to each building separately, or equip each staircase entrance in case of larger buildings. This would be a reasonable compromise between lowering the cost of metering and still putting the meter close to the consumer. All consumers are jointly responsible for heat consumption behind the meter, which includes building-internal heat losses, and—in case individual heat meters are installed—any consumption that is not registered by the flat-wise meters. They would be responsible for bill payment, and the total costs would be distributed among them based on square meters.

The main reason for installing heat meters and introducing consumption-based billing is to give heat consumers incentives to monitor and influence their heat consumption. To accomplish the latter, heating systems need to be equipped with *controls*. Temperature-compensated controllers at building-level substations and a well-balanced piping network provide constant indoor temperatures in each apartment, provided there are no significant variations in the heat load of different rooms, due, for example, to solar radiation or internal heat gains. Since these factors are usually present, apartment-level controls, either in a central location or radiator-based, are required as well. In single-pipe systems, bypasses need to be installed when radiator valves are used in order not to cut off heat supply to other radiators on the same string. The use of controls in a centralized heating network that works according to the supply-driven, constant flow principle will change the system to a demand-driven, variable flow mode as soon as a sizable share of consumers employs controls. This provides the essential link that will enable the realization of energy savings all the way from the point of heat consumption to the heat source.

Initial experiences in China with heat meters and controls have often been disappointing, since many of them failed after a short period. The reasons are manifold, ranging from immature technology over bad water quality to insufficiently trained staff and uninformed consumers (see, for example, the experience in Baotou, Box 2.10). It is thus important to ensure that meters are reliable, tested, calibrated and properly installed and maintained, and that the underlying heating system is of a quality that is sufficient for metering (with special emphasis on water quality). One would expect that heat supply companies would have incentives to keep meters in working order when they become part of a generally applied business model.

In the future it would be important to avoid one of the key gaps in metering and consumption-based billing: an uninformed and uneducated consumer. The use of different kinds of metering and control equipment requires substantial behavioral changes of consumers and they need to be nurtured through information and education.

In addition, expectations about the impact of metering and billing need to be managed. Whether consumers' heat bills will be reduced through metering and consumption-based billing depends on many factors, such as the extent of underheating and/or the emphasis on increased comfort, level of pre-reform heating tariffs—or rather extent of cost coverage (if it is low, tariffs would eventually have to go up and with it heat bills). Thus, proponents of heat reform would be irresponsible if they would suggest that one of the results of heat reform would be that heat bills would be decreased for every single consumer. However, on average, it is quite likely that heat consumption would go down, and with it, heat bills.

Issues in Consumption-Based Billing

Heat-contract Modalities

DH companies prefer to deal with a smaller number of customers and thus contracts. In Western Europe, but also in Poland (see Box 2.8), contracts are usually of a collective nature, with the heating company signing a contract with an entity that represents a group of households (called a *collective contract* hereafter), such as a homeowners' association or a housing management company. In this case, individual households do not deal with the heating company directly. They pay heating bills to the intermediary that represents them, who in turn remits the heating company according to contract terms. In Eastern Europe the rule seems to be *individual contracts*, with the heating company directly responsible for serving each individual household and each household in return responsible for payment to the heating company.[42] With computerized customer accounting and meters that can be read remotely, billing can be done as easily for 100,000 customers as it can be for 100. Box 2.11 provides an example from Bulgaria, where monthly billing of individual consumers has been introduced. Collection of full payment, however, tends to be more costly for individual contracts compared to collective contracts due to problems with enforcement of individual payment when the connection is collective and individual disconnection is technically difficult and costly. As an incentive to enter collective contracts a DH company could, for example, charge a fixed collection fee that would be the same for each contract, independent of the capacity contracted, or the collection fee could be included in the fixed charge, with discounts

Box 2.8 Collective Heating Contracts in Poland

DH companies deal directly with housing cooperatives and not with individual building tenants. DH companies deliver heating at the building substation level, and cooperatives are responsible for delivering the heat to the individual tenants through the building internal heat installations. The cooperatives collect, on a monthly basis, the rent and other utility and building expenses (including heating, domestic hot water, water and sewage, building management, and building maintenance and renovation) directly from the tenants and any nonpayments by individual tenants are first covered by the cooperatives' reserves and then recovered from the tenants through specific repayment arrangements. . . . The role of the Polish housing cooperatives in contracting directly with DH companies has been a significant factor (in addition to income growth [and social support programs for low-income families in all municipalities]) in creating a mechanism for DH companies to ensure the adequate collection of domestic heating accounts.

Source: ESMAP 2001.

[42] Independently of whether contracts with customers are on a collective or an individual basis, they usually exist together with general terms and conditions for heat supply in most European countries. The general conditions also describe the general obligations and liabilities of both supplier and consumer regarding the service quality. Written contracts should specify more detailed agreements, for example, about supply temperature, length of the heating season, if applicable. For example in Germany, general conditions for provision of district heating (Allgemeine Bedingungen für die Versorgung mit Fernwärme) have been established by governmental decree (Verordnung des Bundesministers für Wirtschaft vom 20. Juni 1980 (BGBl. I S.742)), and all contracts with non-industrial consumers are subject to those general conditions; see www.agfw.de.

Box 2.9 Heat Metering and Consumption-Based Billing in Tianjin

Heat metering with different technologies has been applied in demonstration projects in Tianjin since 1997. Typically, apartments in new buildings are now equipped with horizontal heat piping that allows metering the heat supplied to each individual dwelling. However, in practice, very few have actually installed meters and, so far, there was no tariff system in place that allowed the consumption-based billing of individual apartments. A simple form of consumption-based billing has been applied for a period of six heating seasons in several demonstration areas with buildings complying with building energy efficiency standards. Households still had to prepay their heating fee based on square meters. Those households that used less heat than indicated by the average heat consumption index of all types of residential buildings in Tianjin were reimbursed for a share of the reduced consumption; those who used more did not have to pay in addition to the prepaid amount. The heat metering report prepared by the Tianjin working group in 2005 shows that the actual heat consumption of consumers in the demonstration buildings is, on average, substantially below the norm consumption assumed by the heating companies for those types of buildings. During the five years of piloting heat metering and consumption-based billing, 64 percent of all apartments in five demonstration buildings involved in the pilot received refunds on their heat bills, amounting to about 30 percent of the original bill revenue. In two buildings using heat evaporation meters for cost allocation, simple compensation factors were applied differentiating between apartments on different floors and with different exposures. For the 2005 to 2006 heating season, the municipal heating office determined to use the following compensation factors:

- all flats on the last floor get a reduction of 40 percent
- all flats on the first floor get a reduction of 30 percent
- all flats located at the building corners get a reduction of 20 percent.

Compensation factors will likely not be cumulative; the higher factor will be applied. Once the metering results of the 2005/06 season have been evaluated, the above factors could be corrected.

Source: Tianjin Experts Group (2005) and personal communication from Tianjin Heating Office.

for large connected loads (see Kalkum 2003 for an example).

In China, individual contracts between consumers and providers of communal services such as centralized heat are legally mandated. The collective contract modality may, however, be preferable to the individual contract modality, especially considering the current transition from welfare- to market-based heat supply. Most importantly, housing management companies or the homeowners' associations may be more effective in collecting bills from individual households (see the example from Poland in Box 2.8), since they are more in touch with the communities they represent and may possess means and ways to follow up on bill collection that are not available to the heating company.

Allocation of Heat Consumption and Costs to Consumers

All heat-metering options require that the total heat consumption of a building is allocated between the individual consumers. Individual heat meters without a building meter are the exception; billing of heat consumption could be done directly according to the readings of the meters. Flat-wise heat metering seems to be the fairest method as the heat supplied by the heating company can be measured directly at the apartment with a satisfying precision. Consumers may be more prepared to accept such a metering approach since it is similar to the process of metering electricity consumption. However, flat-wise heat metering measures only a portion of the heat supplied to a flat, since it cannot register the heat that is delivered by

transmission from neighboring flats or from pipes crossing the flat. Individual heat meters also do not report building-internal losses. Thus, even when individual heat meters are installed, it might be advisable to use them only for heat allocation purposes in addition to a building heat meter.

Sharing fixed and variable costs within a building. The total variable and fixed costs can unambiguously be determined at the substation or the building entrance where a meter and a flow-limiter (see footnote 36) are installed. Variable costs are determined in accordance to the metered energy and fixed costs can be determined in accordance to installed substation capacity (or total area if capacity is not available; see page 39). If flat-wise heat meters are installed, the variable costs for each flat can be distributed in accordance to meter readings of the individual meters. There will always be differences between the readings of centralized meters and the accumulated results of the individual meters due to metering errors and building-internal consumption and losses. Such difference could be distributed among flats by m² or kWh. If heat cost allocators are installed, the variable costs are distributed in accordance to the readings of the cost allocators. Heating costs include building-internal losses. The fixed charge is typically distributed among flats in accordance to the heated area, since the maximum heat load of a single flat is usually not registered by a heat meter.

Sharing Fixed and Variable Costs between Various Buildings. A meter installed for each building or staircase measures the heat consumption of the respective facilities, which can however differ substantially from building to building due to design- and construction-related factors. The question arises as to whether consumers should be billed strictly in accordance to the measured consumption. In Western and Eastern Europe, each building (or more precisely, the collective of the apartment owners who have the obligation to maintain the building) is regarded to be responsible for its own heat consumption, and compensating factors are not applied to balance heating costs among buildings with significantly different heat consumption. It is recommended to apply the same practice in China.

Since low-income households are more likely to live in buildings without energy-efficient features, it is important to mitigate the financial consequences of high heating costs due to very high heat consumption (if caused by design- and construction-related factors) through an appropriate social assistance program (see Chapter 6). Building reconstruction programs should focus on buildings with very high specific heat consumption, and provide additional financial support to low-income flat owners so they can participate in such energy efficient reconstruction (see page 70). The National Experts Team went one step further, suggesting that for existing buildings consumption-based billing should only be introduced in combination with energy-efficiency retrofits. This proposal could hamper the introduction of metering and consumption-based billing significantly. It would be very costly and, since the payback time for energy-efficient building rehabilitation is quite long, financing for such a large program would be difficult to raise. Instead, experience with metering in existing buildings should be gained and on this basis, cost-effective rehabilitation measures should be proposed, including the design of innovative financing mechanisms. Projects along these lines are currently implemented by bilateral and multilateral donors in Harbin, Tangshan, and Baotou.

Recommendations. The key to making heat a commodity is to meter it and to bill customers according to consumption. In order to achieve this quickly and involve as many consumers as possible, meters at the building level should be installed as soon as possible. The meter readings constitute the basis for calculating the costs of heat consumption of the entire building, which can then be distributed among the individual consumers in a variety of ways. Flat-wise heat meters can be used as well as simpler and less expensive heat cost allocators. For a transition period, heating costs could also be distributed by flat area.

Box 2.10 Heat Metering in Baotou

An analysis of heat metering data in several buildings in Baotou (Inner Mongolia) was performed as part of an effort under the World Bank/GEF "Heat Reform and Building Energy Efficiency" project to identify cost-effective renovation measures for existing residential buildings. Over a period of four heating seasons an increasing number of apartment heat meters failed for various reasons ("heating meters are jammed and the data is zero; heating meters are spoiled and screens do not show; door locks are changed and staff can not get in; there are much sundries and the data cannot be read"). Apartment heat consumption in the buildings, which were all built without exterior insulation, varies considerably; the position of the apartment is significant in determining the consumption, which varies on average about 30 percent.

Illustration of different kinds of apartment positions

1	3	. . .	3	1
2	5	. . .	5	2
	. . .	. . .	. . .	. . .
2	5	. . .	5	2
1	4	. . .	4	1

1: corner angle position
2: gable wall
3: top position
4: bottom position
5: middle position

Average energy consumption of room in different location

Location type	1	2	3	4	5
Average consumption (w/m2)	36.66	32.46	30.87	28.19	27.10

Source: Beijing Institute of Civil Engineering and Architecture (2006).

Existing differences in the heat consumption of different flats or different buildings should not be used as a pretext against consumption-based billing. This issue still needs to be fully researched in China. Results of metering pilots—such as in Baotou—should be analyzed carefully and the reasons for deviations should be investigated (see Box 2.10). Under a two-part tariff system, only about 50 percent of the energy bill will be affected by such differences in consumption. In addition, the application of compensation factors within buildings could be considered.

Use of compensation factors for heat consumption. It is a common argument against consumption-based billing that differences in heat consumption are mostly design- and construction-related. Since these are factors that are beyond the responsibility of each consumer, billing strictly according to consumption would be unfair. Although there is no doubt that construction- and design-related factors have an impact, it is currently impossible to determine to what extent these factors contribute to such differences, since comprehensive empirical analyses are not available. The following principles should be applied to determine compensation factors:

- Compensation factors should not compensate for heat energy waste caused by consumer behavior.
- Compensation factors should not compensate for heat losses that can be removed by the individual consumer (for example, by window sealing) at low cost. Of course, again the affordability issue has to be considered. However, even if heat losses are due to old windows, which are relatively costly to replace, it should be considered that a corresponding compensation factor would remove any incentive to replace them by new ones.
- Compensation factors should usually only compensate for heat losses that affect more than one flat (e.g. bad insulation of outer walls, roofs, etc.).

- The system of compensation factors should be as simple as possible and transparent for consumers.

In several countries in Western Europe, compensation factors are not used for three reasons. (i) In well-insulated buildings heat-consumption varies only to a small extent, due to behavioral factors; (ii) when consumers buy or rent an apartment, the price does reflect to some extent the location and heat consumption of the unit; and (iii) the fixed part of the heat bill takes into account diverging heat consumption. When heat requirements differ substantially and cannot be changed with reasonable costs, a higher share of fixed cost (i.e., closer to 50 percent) could be recommended (JP/CEEB 2002).

It is important to point out that using heat compensation factors to achieve perceived fairness in billing will defeat much of the simplicity offered by metering options C and D, and may not be advisable in these situations. Even in option B, the use of compensation factors may contribute to a lack of transparency for the consumer rather than enhance fairness of billing.

Conclusions. Heat consumption can never be attributed exactly to one of several end-use points in one building. Using compensation factors to achieve a fairer allocation of heat costs is justified only if large discrepancies in heat consumption are found between similar dwellings in different locations of a building. This is more likely to occur in poorly insulated buildings. Use of compensation factors may not be advisable for well-insulated buildings, especially in owner-occupied buildings where the apartment location factor is already considered in purchasing decisions. Furthermore, the fixed part of a two-part heating tariff already takes into account to a large extent that heat consumption might vary depending on the location of an apartment in a building and other factors.

Billing, Collections and Payment Terms

Consumption-based billing requires considerable investments not only in equipment, but also in related services. Independently of having collective or individual contracts (see page 52), DH companies in Europe usually do not carry out heat cost allocation and preparation of heating bills for individual households, as this is not considered their core business. These services can, in general, be provided by separate billing companies on a competitive basis. For example, in Sofia (Bulgaria) 16 companies fulfilling certain criteria were selected by the DH company and proposed to customers in a letter with information on heat metering and consumption-based billing.

Under consumption-based billing, in addition to the charges according to the heat tariff, several additional cost components can be part of the heating bill of the individual consumer (see JP/CEEB 2002):

- Charge for heat losses in the building-internal piping network downstream if only apartment heat meters are used. For example, in Korea 10 percent is added to the energy charge to cover these losses. Some German DH companies charge slightly higher retail tariffs for customers with apartment meters than, for example, to an entire building.
- Heating costs of common areas. In Western Europe, where common areas are usually heated, this represents around 30 percent of the total space heating costs of a building;
- Installation and maintenance costs of the individual metering devices; and
- Cost of the billing service (i.e., cost of reading the meter), calculating the household charges and preparing the bills for individual households.

When consumption-based billing is first introduced, the government or the regulator can accelerate its acceptance by consumers by establishing a basic framework for heat cost accounting and individual heat metering and by certifying billing companies so that consumers are assured that these are competent and that heating bills are calculated according to a sound methodology.

Chinese customers have to pay the total heating bill for the entire heating season at

Box 2.11 Consumption-based Billing on a Monthly Basis

In Plovdiv, Bulgaria, the building meters and electronic heat cost allocators (existing in 92 percent of all residential buildings) are read remotely on the first day of every month. The billing department of the DH company separates the heat and hot water consumption and sends the data on the fifth day to the billing company. It performs the billing for the households in each building and sends the breakdown per household (customer) back to the DH company between the eighth and tenth day. The DH company sends the bill out to each household on the twelfth day and the customer has fourteen days for payment without incurring any interest charges.

Source: Meyer (2003).

the beginning of the heating season. For even earlier payment, many heating companies offer discounts. Prepayments are justified by heating companies as a fund for buying fuels and other materials needed for the coming heating season, but they can constitute significant hardship, especially for low-income households. With payment responsibility shifting now to households, insisting on prepayment could contribute to lowering the willingness to pay and thus collections.

In the future, Chinese heat supply companies need to become more flexible and offer a broader range of payment options. For payment of fuels and other inputs, they should rely more on short-term loans. The financing costs have to be accepted as justified costs of heat supply. This would also be in compliance with the commercialization of the heat supply business.

Companies in Western and Eastern Europe offer various payment options: In unmetered DH systems, payments for heating are usually made every month of the heating season based on the size of the living area. In case of severe nonpayment problems, prepayments or lump-sum payments are required.

In metered DH systems, two options prevail. (i) Customers either pay in equal monthly installments over 12 months, based on the heat consumption of the previous heating season, and reconciliation with the actual consumption takes place at the end of the heating season. This is typical in Western Europe, where heat and hot water are paid together with the maintenance fees by inhabitants of multifamily residential buildings. For consumers, it has the advantage of spreading out the payments evenly over the year, thus avoiding very high heating bills and, potentially, payment problems during the two or three coldest months. (ii) Alternatively, meters are read every month and customers are billed according to the actual consumption every month during the heating season. The latter has become increasingly popular with the wider application of remote reading of heat and electronic heat allocation meters. Customers seem to appreciate the direct relationship between consumption and payment. Box 2.11 describes the process of monthly metering and billing in Plovdiv/Bulgaria.

It might be a good marketing strategy if the heating company gives customers a choice of payment cycle. This might lower the extent of late payments. It is recommended, however, that those customers preferring to be billed monthly according to metered readings have metering devices that can be remotely read. Otherwise, the billing costs would be too high (JP/CEEB 2002).

Impacts from Heat Metering and Consumption-Based Billing

From a public policy point of view, the main purpose of adopting heat metering is the creation of a market incentive for end-use energy conservation. This incentive to realize cost savings may directly result in energy savings. Experiences from Western and Eastern Europe show that consumer control and metering of heat consumption and consumption-based billing will typically result in a reduction of heat demand by some 15 to 30 percent. Much of this can be achieved with metering at the building level, which should be widely and quickly implemented as a minimum requirement.

Heat consumers in Poland, for example, adopted energy-saving measures in large

Box 2.12 Energy Savings and Reduced Heat Bills in Poland, 1992 to 2000

Figure 2.7 Heat Sales per m² in Poland and Finland, 1992 and 1999 (in GJ/m²)

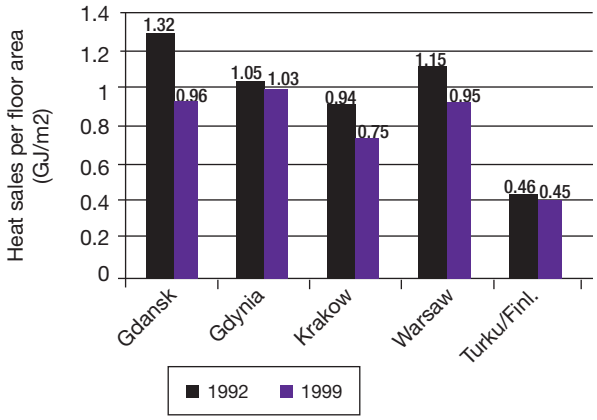
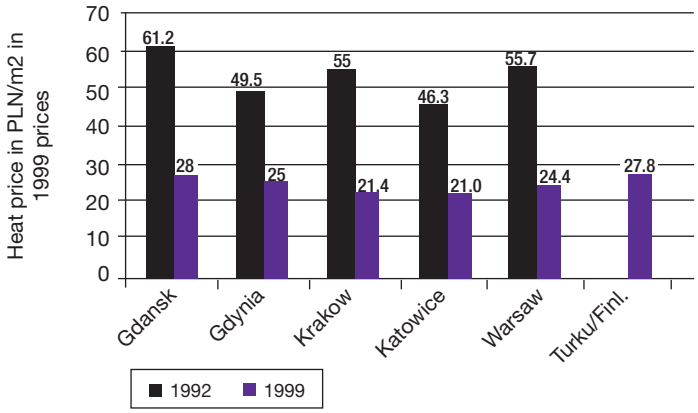


Figure 2.8 Heat Prices per m² in Poland and Finland, 1992 and 1999 (in PLN/m² in 1999 prices, without VAT)



Note: 1$ = 3.72PLN; 25PLN = 6.7$ = 55yuan/m².

Source: Based on World Bank 2000.

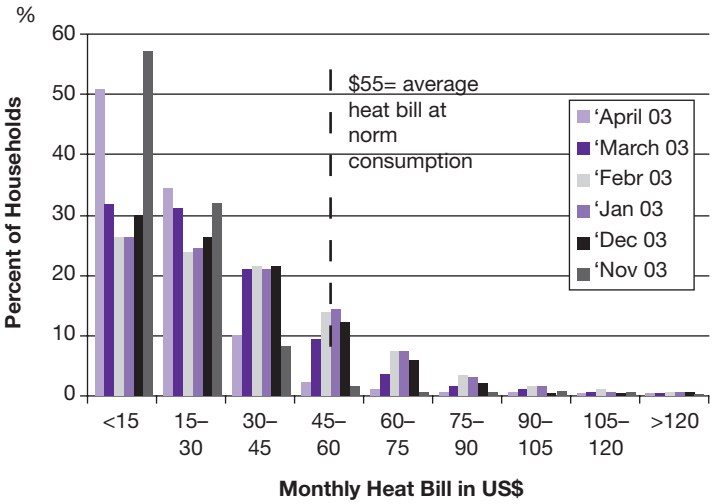
The government of Poland implemented energy-sector reforms under which the full payment for heat gradually became the responsibility of households. DH companies installed heat meters at the building level, a two-part tariff was introduced and households began to use heat more efficiently by investing in controls, heat allocation meters, better windows and some exterior building insulation (but not renovation of internal piping). The share of renovated buildings is fairly high now; for example in the city of Gdynia it amounts to approximately 70 to 75 percent of the residential building stock. The efficiency improvements by consumers, together with the technical, operational, and management improvements in DH supply, resulted in an average 18 percent drop of heat sales per m² of heated space in four cities participating in a World Bank project (see Figure 2.7). With strictly regulated heat tariffs (see Figure 3.1) this resulted in an average decrease in costs of heating a given apartment area by 55 percent (see Figure 2.8). Even though some of the real decrease in prices didn't reach consumers due to an increase in the VAT rate at the same time, the remaining cost reduction helped to make the removal of the subsidy less burdensome to households. Net consumer prices per square meter of heated area are now comparable with prices in Finland. The price drop has improved competitiveness of DH, and DH has attracted additional customers. The combination of comprehensive investment programs and strictly regulated retail heat tariffs did, however result in serious financial difficulties for all DH companies involved in the World Bank project, including a substantial decrease of the gross margin (see footnote 43 for the definition).

numbers after metering was introduced (see Box 2.12 with Figures 2.7 and 2.8). In a rapidly growing economy such as China, providing incentives through metering and consumption-based billing could further lead to energy-smart decisions on home purchasing, driving up demand for more energy-efficient buildings. Thus, the cost effectiveness of achieving potential energy savings becomes a key criterion to judge which type of heat metering is justified (i.e., if the social benefits of potential energy savings outweigh the additional costs). In China, the Tianjin experience with substantial heat bill refunds for most consumers in buildings built according to BEE standards confirms that heat metering and consumption-based billing is indeed generating benefits for those consumers (see Box 2.9).

Box 2.13 Impact of Consumption-based Billing on Heating Bills in Bulgaria

In Bulgaria residential heat and electricity expenses have gone up to a point where they amount to about 40 percent of household income. Many households have, however, during the past few years managed to cut their consumption and their expenditures down considerably. Figure 2.9 shows some results of implementing metering and consumption-based billing for heat on the basis of a two-part tariff in Bulgaria. For an average apartment with two rooms, the average monthly heat bill would have been US$55, had households been billed per m² according to consumption norms. But since buildings are now equipped with heat meters and households have thermostatic radiator valves (TRVs) and heat allocation meters, the heating bills of most households are far below this amount. Even during the coldest months of the 2002/03 heating season—which was one of the coldest in memory—almost three quarters of the residential customers of the Plovdiv DH company paid less than US$45 per month, and in the warmer months of the heating season this was true for more than 95 percent. This result shows that households actually manage their consumption and thus their expenditures, by turning heat down or lower during all or part of the time, when the combination of technology and price incentives are in place.

Figure 2.9 Distribution of Monthly District Heating Bills in Plovdiv, Bulgaria, 2002 to 2003



Source: Plovdiv DH Company and State Energy Regulatory Commission.

As a result of energy savings, consumption-based billing can also have a major impact on consumers' heating bills. The example from Bulgaria in Box 2.13, which shows the substantial decline in monthly bills in Figure 2.9, is typical for many other cases in Eastern Europe.

However, once consumers can control the temperature level, it is expected that some heat consumers who received a low level of heat in the past will choose more comfort, which may result in higher heating bills as well. The example of Lithuania in Box 2.14 is a case in point. If a consumer chooses to increase the indoor temperature, for example, from 16°C (the currently required minimum supply temperature in Chinese heat supply systems) to 20°C, heat consumption would increase by about 13 percent. Savings due to consumption-based billing could offset such increases.

What happened in Bulgaria and Poland is typical for DH systems where heat metering and consumption-based billing have been introduced. Heat consumption goes down and in the short term DH companies will experience reduced sales and revenues. In the mid- to long-term they can generate profits again by modernization investments, thus improving efficiency and reducing costs of heat provision and by connecting new customers to the network. For Chinese heating companies, the impacts of heat metering and consumption-based billing could turn out to be much more beneficial since new housing developments and thus new customers are materializing every day. With heat loads and consumption of existing customers decreasing, new capacity and supply does not have to be provided completely from new infrastructure, provided that local heat markets are restructured in a way that gives

Box 2.14 Thermo-Renovation in Lithuania

Between 1996 and 2001 homeowners and homeowner associations were participating in the Lithuania Energy Efficiency and Housing Project, financed by the World Bank, to finance residential building energy efficiency improvements through a credit-line. In 96 monitored projects (of 229 in total) investments varied from less than US$250 per apartment to more than US$3,500 with an average close to US$1,000. Among the investments were rehabilitation of DH substations, change of windows, weather proofing of roofs and exterior walls. Energy savings showed a very large spread, from significant additional consumption to more than 50 percent reduction with an average value for a normal year of 17 percent (without adjustment for comfort change). In reality, many homeowners preferred increased comfort to savings and raised indoor temperatures. A rough estimation showed that without temperature increases average energy saving would have been 25 percent. Based on a survey, 56 percent of respondents had their heat bills decreased and 48 percent reported improvement in housing quality. Average payback time of investments (without taking into account increased comfort or other imputed values such as reduced maintenance costs, extension of asset life, or increased property values) amounted to 17 years. Taking into account subsidies through a grant of 30 percent of the loan principal and a VAT exemption, average payback time of the investments was in fact reduced to 12 years.

Low-income households were initially reluctant to participate in the project and take on long-term financial obligations. Starting in 1998, it was possible to apply the subsidy to the debt obligations of low-income households. This removed an obstacle to their participation.

Source: World Bank 2002 and HUDF 2002.

companies and existing infrastructure a chance to supply new housing developments.

Recommendations for China

The experience with heat metering during the past five years in China, albeit still quite limited, suggests that the recommendations of the 2002 report still hold, but possibly with a reduced emphasis on apartment-level metering as the ultimate goal: "Although achieving individual heat metering may be the eventual goal, the national policy should leave room for the level of metering (building-based vs. apartment-based) at the initial phase of implementation to allow for learning and capacity building, as well as to leave open the metering options to allow for multiple choices of technologies and let the heat customers, suppliers and the market determine the proper applications at different locations. Therefore, a gradual approach in adopting heat metering and consumption-based billing would be appropriate for China. This also reflects international experiences in similar transitions. The government might structure the implementation process in two steps.

1. "As a first step, it should be required to meter all buildings, new as well as existing, or at the very minimum other wholesale units such as heat substations. This will enable the basic commodification of heat through the previously described collective heating contract modality, provide direct incentives for heating companies to improve the efficiency of heat production and delivery, and should also provide some incentives to realize energy savings on the consumption side. Thus, building-level metering should be made a minimum requirement for all central heating systems.
2. "In the second step, the objective is to realize the potential end-use energy savings by adopting apartment-level heat metering, which is considered essential for motivating heating energy conservation among end-users. There will be cases in which consumers may opt to combine the two steps and go

directly to apartment-level metering. This should be encouraged if the conditions are ripe for such attempts. But in general delaying the requirement of apartment-level metering a few years would be a practical policy. In a few years time after the first step, the results of the demonstration projects and the improved infrastructure for heat metering and billing would provide a solid base for introducing individual heat metering. Moreover, at this point the development of less expensive and more reliable small heat meters should have progressed to enable their use on a wider basis."

3 Improved Heat Price Administration System

A New Regulatory Framework for the Centralized Heating Sector

In China, municipal agencies are currently responsible for setting heat prices and for supervision of the local heat supply sectors in general. Changes in heat prices require a fairly elaborate procedure, involving several local government departments, public hearings, and finally a political decision by the local government. There is consensus that the government should continue to be involved in setting heat prices "to restrict monopoly earnings and protect the benefits of the residents" (National Experts Report 2005), but through a more transparent, flexible, and efficient process.

Lessons from Eastern Europe that are relevant to the regulation of heat pricing follow:

- The regulatory framework needs to ensure that tariffs and the tariff setting process are simple and transparent in order to make the process manageable and to increase the acceptance of tariff changes by consumers, politicians and the regulated companies. Any regulation should be designed in a way that allows quick reactions to changes in the market through reduced details in legislation and greater delegation of powers to the regulatory agency. Although some of the smallest companies could be exempted from regulation, it is important to treat all DH companies equally regarding, for example, tax status and application of cost accounting standards.
- In bigger countries, locally or regionally based regulation may be preferable to a national regulatory agency. Municipal level regulation is less than ideal since it means that municipalities carry out several functions—not only are they frequently the owners of DH companies, but also the regulators. Conflicts of interest could be the result if necessary checks and balances are not in place. In addition, the necessary experience to efficiently perform regulatory functions is frequently scarce at the local level. Ensuring the independence of local regulators from local politics and capacity building for them would thus be very important. A national-level regulator with regional or local offices may be an alternative for the DH sector. With regulation at the subnational level it is recommended that one agency gather nationwide information, provide benchmarking, and inform consumers about the results of the regulatory process. Of particular importance would be comparisons of heat prices and various efficiency measures of heat supply in cities with centralized heat supply.
- Even if regulation is carried out at the subnational level, the following methodologies and sample contracts should be developed on a national level: (i) uniform rules for cost accounting and cost allocation, (ii) a nationally applicable methodology for tariff setting, including computation of the heat supply costs, (iii) standard supply contracts for general or tariff customers, and (iv) standard connection and supply conditions, including a definition of minimum requirements for service quality.

- Coordination between regulators of CHP companies—usually the regulator for the power sector—and DH companies is important. This concerns at minimum the methodology for CHP cost allocation.

During this project only basic improvements of the regulatory framework—as they relate to making heat pricing more effective—were investigated. The Chinese government (MOC and NDRC) have issued a national heat pricing methodology (Heat Pricing Management Method) in 2007. A scoping analysis of more general issues to be resolved in the development of a new national regulatory framework for the centralized heating sector has been carried out jointly by experts of MOC and the World Bank in 2005/06. Based on those results, more detailed investigations will be the subject of a new collaborative effort between MOC and the World Bank (ESMAP), starting in late 2007.

Flexible Heat Price—Automatic Partial Adjustment

Heat tariffs in China used to be fairly stable during long periods of time. Despite significant increases in the costs of major inputs, heat tariffs for residential buildings in many cities had not changed between the mid-1990s and early 2000. There was no built-in mechanism to ensure that tariffs are adjusted in accordance to specific exogenous cost increases or general inflation. Automatic partial price adjustment is important from the perspective of securing sufficient financing of DH companies, providing a reasonable continuity and planning security and avoiding overt political influence over heat prices.

This project was implemented during a time of steep coal price increases (see Figure 3.2a). Most city working groups proposed some kind of price adjustment formula, but not as an automated mechanism to adjust heat tariffs. Existing price approval procedures would continue to be applied. Both Taiyuan and Tianjin advocated tariff adjustments in case of considerable increases of the variable costs. Most companies would be able to cut expenses and increase the efficiency to compensate for smaller price increases. The national experts took these proposals a step further, advocating quasi-automatic heat price adjustments to changes in input prices.

In many countries in Eastern Europe where heat tariffs are regulated, automatic partial adjustment of heat tariffs has been implemented after a period when governments were very reluctant to increase heat tariffs for fear of contributing to inflation pressure or increasing affordability problems. Box 3.1 presents the experiences in Poland. These also provide another lesson, namely about the importance of balancing the interests of heat consumers and suppliers when setting heat tariffs. An analysis of the distribution of benefits of the World Bank financed investment project mentioned in Box 2.12 shows that most of the project benefits (and a substantial part of the DH companies' profits) were transferred to heat consumers due to the government's control of tariffs. As a result of the limited tariff increases, the profitability level of the DH companies hardly improved. This would make it difficult for the companies to access commercial loans for further necessary investments. "It is therefore important that further tariff increases, combined with further efficiency improvements, be sufficient over time to enable the DH companies to generate adequate funds to meet their debt service, make a contribution toward investments and pay a reasonable dividend to equity holders." (World Bank 2000, p. 9)

Recommendations. Price adjustment formulae should allow adjusting the tariff to certain input price increases without prior official approval. To prevent any automated adjustment of tariffs to inflation, price adjustment formulae do not necessarily have to comprise all cost items. Moreover, adjustments could be limited to only once or twice per heating season and/or to input price increases exceeding a certain ceiling (e.g., fuel prices increases of more than 5 percent compared with the initial price).

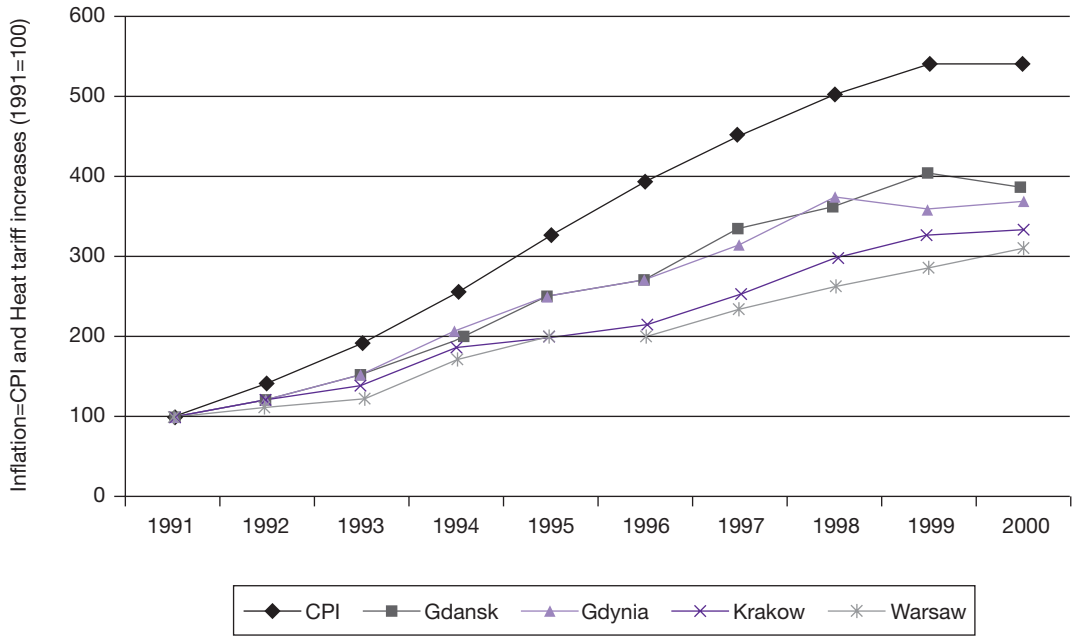
Box 3.1 DH Tariff Increases below Inflation in Poland, 1991 to 2000

The *Polish* Ministry of Finance fixed standard prices for space heating and domestic hot water (DHW), determining the national maximum tariff that DH companies could charge their residential customers. The standard prices were in force until the end of 1997, at which time the costs and therefore also the tariffs of most DH companies were below this maximum tariff. After standard prices were abolished, for three years annual tariff increases were limited to 15 percent. In fact, the average tariff increases approved by the regulator in 1999 and in 2000 were below inflation, resulting in a decrease in real tariff levels. Only in 2000 real tariffs increased again. The limited tariff adjustments resulted in substantial reductions of most of the DH companies' gross margins. Figure 16 compares the increase in the Consumer Price Index (CPI), 5.4 times from its 1991 level, with the increase in DH consumer prices, which have risen 3 to 4 times from their 1991 level in the four cities participating in the World Bank project. The consumer has thus benefited from lower real unit price of heating. The heat prices in the cities having received WB financing support are on average lower than in other Polish cities.[43]

In 2000 the secondary legislation in Poland was changed to add more flexibility to the tariff setting process and reduce the workload of the regulator. Tariffs could be approved for a maximum of three years, including an adjustment formula, and they would be based on planned justified costs instead of historic costs.

Source: World Bank 2000.

Figure 3.1 DH Tariff Increases and Inflation in Poland, 1991 to 2000



Source: World Bank 2000.

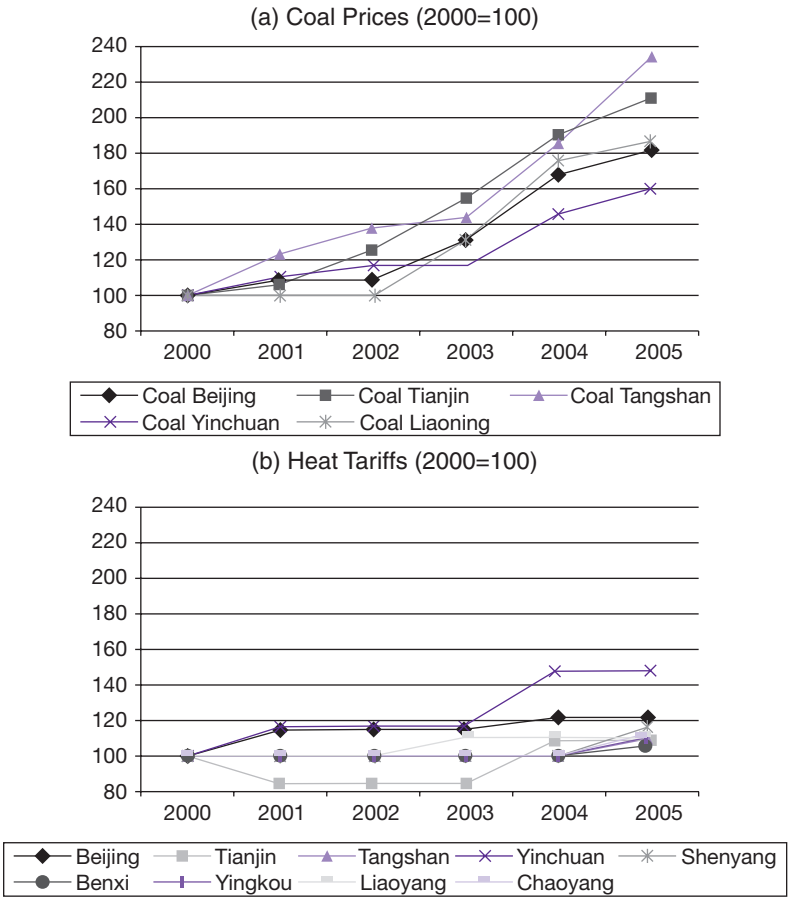
More generally, applying a price-cap mechanism in China's centralized heating sector, similar to the one in force in Lithuania (see Box 2.5), should be considered. Although encompassing some aspects of partial automated heat price adjustment, the use of price-cap tariffs would go beyond it. An initial (baseline) tariff would be approved by the regulatory authority

[43] See ESMAP 2000 and World Bank 2000. Gross margin is defined as gross income divided by net sales, expressed as a percentage.

(currently the municipal government) for each individual heating company, but for a period of three to five years, including a price adjustment formula for the same period. Thereafter, the baseline tariff and the price adjustment formula would be recalculated and approved by the regulatory entity. For a limited period of time (i.e., until the next approval of the baseline tariff), this tariff system would allow the heat supply companies to generate extra profits by improving the efficiency and performance of the company.

Implementation. In October 2005, NDRC and MOC issued a joint regulation, allowing the partial automatic adjustment of heat prices in case of increasing coal prices. If the coal price increases more than 10 percent over the period of at least one year, heat-generation tariffs can be increased according to the coal cost share in total heat-generation cost without going through the established channels for municipal heat price approval. Heating companies should bear 10 to 30 percent of the cost increase as an incentive to improve efficiencies and lower coal consumption. The increases in coal price and heat generation tariff should also be reflected in the end-user tariff; in this case a public hearing would be required. Local governments and heating companies seem to have acted quickly in adopting the partial automatic heat price adjustment clause. In many cities heat tariffs were increased for the 2005 to 2006 heating season after years of rising coal prices and flat heat tariffs; see Figures 3.2a and b.

Figure 3.2 a–b Coal and Heat Price Development 2000 to 2005



Source: Based on data from MOC and the Liaoning Project Management Office.

Note: Shenyang, Benxi, Yingkou, Liaoyang, and Chaoyang are all located in Liaoning Province, and the same coal price applies for all cities.

Coordination between Power, Bulk Heat, and Heat Pricing—Role of Cogeneration

Many centralized heating systems in China receive their heat from cogeneration plants and heat purchased from such plants is thus an important cost factor. The use of cogeneration is, however, less important for Chinese DH systems than, for example, for DH systems in the European Union countries (see para. 85). One reason for the underutilization of CHP in China's DH systems is the high cost of cogenerated heat. The fact that Chinese DH systems do not supply domestic hot water is one factor contributing to the high costs of delivered heat. Depreciation charges are typically much higher than for HOBs, and electricity gets most of the benefits of the cogeneration process. The potential for energy savings from cogeneration as compared to heat supply from HOBs could be realized to a much greater extent if the applied cost allocation method would be more favorable for heat rather than for power.

More generally, politicians and regulators should keep in mind that within an increasingly market-based framework, both products from CHP plants need to be able to compete with heat and electricity from other sources. If it is decided to promote CHP, for example on the basis of environmental, resource-saving and energy security considerations, the cost-allocation method for CHP plants must be in line with this policy preference.[44]

Heat provided from cogeneration plants is an important cost factor in many DH systems. Therefore, its pricing could have a significant impact on retail heat tariffs. For example, in Kiev/Ukraine the cost allocation in CHP plants providing heat to the Kiev DH system was changed in 1998, resulting in a decrease of the average retail tariff from US$22/Gcal to US$17/Gcal (World Bank 1998).

It is *recommended* to develop a pricing methodology for heat and electricity from cogeneration that shares the benefits between heat and electricity in a way that maximizes the economic benefits from cogeneration. Such methodology would have to be developed together with the regulatory agency for the power sector.

[44] For example, within the European Union CHP installations now receive preferential treatment. (http://europa.eu.int/eur-lex/pri/en/oj/dat/2004/l_052/l_05220040221en00500060.pdf).

4 Transfer of Payment Responsibility to Consumers, Transparent Subsidies, and Social Support for Low-income Consumers

Within this report, consumer payment responsibility and transparent heat subsidy are investigated as the final part of the Chinese heat-pricing reform agenda. For the Chinese government and experts, it constitutes a most fundamental and important part of the reform agenda, to be implemented first.

Transfer of Payment Responsibility from Work Unit to Consumer

In the big cities in China's northeast where centralized heating started, it became part of the work-unit-based social welfare system. Heat was provided for free as part of housing benefits to employees of work-units under the central government, receiving funding from the state budget, such as schools or in SOEs. Heat supply as social welfare was also prevalent in Beijing and in "company towns" relying on one big SOE. In smaller cities or cities outside the northeast where centralized heating started later, heating was not necessarily provided for free by work-units.

With the dismantling of the work-unit-based social welfare system since the late 1990s, housing markets have already become much more market-based. Government employees do not receive work-unit based housing any more and have to acquire their own dwellings. More than 80 percent of residential housing is now privately owned. Transferring the payment responsibilities of housing-related expenditures from work units to consumers would open also these related markets to a market-based approach. For infrastructure services a shift in payment responsibility would have the advantage that the costs of these services might be included in housing purchase decisions. Consumers would consider energy and other resource savings, particularly when the payments for heating, water, and so on are based on metered consumption (see page 59).

Important steps have already been taken across cities in northern China to discontinue the heating welfare system, but in the various cities to a different extent. In the four cities participating in this project the contribution of the employees to the total heating costs varies between 10 and 100 percent (see Table 4.1). Tianjin has been the national leader of this aspect of heat reform, starting the transfer of payment responsibility already in 1999 to 2000 and reaching 100 percent within three years. Irrespective of the ultimate share of the heat bill for which consumers are responsible, in most cities they now need to pay heating bills and request reimbursement by their employers.

In December 2005 the central government issued a two-year deadline for the completion of the transfer of heat bill payment from work unit to consumer (Circular No. 220).

Compensation through Explicit Cash Payments

Under the old welfare system heat was supplied as in-kind labor compensation. It would therefore be logical to transform this into an explicit payment when transferring heat payment responsibility to employees. Although the principle is generally acknowledged and would go a long way in preventing affordability and collection problems, the extent of compensation is controversial and difficult to implement in an equitable fashion. Government employees are the group where the conversion of the invisible to a visible subsidy is most relevant. In many cases additional payments are already forthcoming and discussions center around the extent of compensation: should it be a one-time, complete, or partial compensation, should all future heat price increases be compensated as well, should compensation be provided to each employee regardless of whether other family members also receive compensation? For enterprises where payments to employees do not already implicitly include a component for heating, compensation is recommended, but cannot be enforced. In SOEs that are in financial trouble, payment for heat to employees or to pensioners is very unlikely to materialize. These heat consumers, those who are unemployed and other poor households not included in the old state-financed system are the ones for whom social assistance should be provided.

In Eastern Europe the transfer of payment responsibility to consumers was generally established at the beginning of the transition period. Consumers did not receive any cash compensation, but heat was usually provided with general subsidies that were gradually reduced with increases in the cost recovery level of heat tariffs. Increasing income levels reduced the burden in general. In most countries, general subsidies have been phased out completely, and only poor households receive social assistance support, as is the case in Western Europe and North America.[45]

Social Support for Poor Heat Consumers

In many cities in northern China the process of making consumers responsible for the payment of heating bills and at the same time adopting measures to subsidize the heat consumption of poor households is well underway. The existing social assistance system based on the Minimum Living Standard (MLS) Scheme, a national transfer program, is used for targeting of heating subsidies in many locations, but rarely are the two systems administratively unified. The main tools of supporting poor heat consumers can be divided into three categories, described in detail in Zhang/Xu (2005):

1. Heat security funds are special local government funds to help low-income and poor households to cover their heat fees. Cities with such funds include Shenyang, Changchun, Harbin, Taiyuan, Qiqihar, Daqing, Anshan, Fushun, Benxi, Dandong, Liaoyang and Tieling.
2. Discounts and waivers of heating fees—the payment of heat bills is shared between consumers, government, and enterprises, for example in Tianjin, Changchun, and Harbin.
3. A few cities have enhanced the MLS scheme by including heat fees into MLS benefits and raising the MLS benefit levels. Cities adopting this practice include Beijing and Yingchuan, but other cities are also contemplating the method.

With heat reform only in its beginnings, the existing systems are necessarily imperfect and several issues need to be resolved in the future:

[45] For a summary on targeted subsidy mechanisms, see Meyer (2003). For more details on Eastern European energy safety net programs see Lovei et al. (2000) and USAID (2003).

Table 4.1 Social Programs in Pilot Cities

	Tianjin	Changchun	Harbin	Taiyuan
Consumer share of heat bill, percent	100	15	10	15
Social Heating Subsidy Programs	50 to 60 percent discounts	Heat Security Fund finances discounts and wavers	Heat Security Fund finances discounts (living area limited)	Heat Security Fund finances discounts of 85 percent (living area limited)
Eligibility criteria	MLS and unemployed households on the margin of MLS	MLS households	9 classes of eligible poor households	MLS households, DH companies and enterprises in econ. difficulties

Source: Based on Zhang/Xu 2005.

- Municipal heat security funds are often underfunded and can provide only limited relief to poor families. In some cities the locally funded heat subsidies already account for a large percentage of total MLS funding (e.g., Changchun 16 percent and Harbin 32 percent). But unlike the MLS scheme, heat security funds rely on local funding sources only.
- Heating companies had to finance a large part of the discounts and waivers of heating fees from the municipality. The financing of a large part of the subsidies to poor consumers is increasingly in contradiction to the requirements of a more commercial behavior of those companies. Indeed, this is changing now with local governments taking over all or some of the financing burden, e.g., in Tianjin.
- The targeting approach leads to inclusion and exclusion errors: 66 percent of surveyed MLS households in the four cities have not received heat subsidies, whereas 23 percent of heat subsidies went to non-MLS households.
- Only a subset of needy households get support in securing basic heating needs. Poor, non-MSL households are rarely covered by subsidies. In Beijing, the government plans to expand coverage to people not covered by MLS but near poverty, such as unemployed, laid-off, and other poor people. With some widening of eligibility criteria now occurring (see Table 4.1), it will be a challenge to maintain simplicity so that the resulting system is not becoming too complicated, intransparent, and difficult to administer.
- With heating subsidies not being channeled to consumers, but mostly directly to heating companies, many consumers complain about bad quality service and a lack of influence on providers.

In each of the four pilot cities basic social mitigation measures are currently in place for many poor households included in the MLS program (see Table 4.1). The low-income population, however, does not usually receive support in paying heating bills from either their work unit or the government. According to the social surveys carried out under this project, the total heat bill is about 23 percent of the income of poor consumers (first quintile) and 10 percent of the income of low-income consumers (second quintile). The self-paid heat bill (i.e., after deducting payments to heat suppliers from employers or government agencies) amounts to 13 percent and 8 percent, respectively, of income (see Figure 1.6). This shows that subsidies are quite effective in reducing the burden for poor households. Few low-income households, however, experience

any relief. A reversal between low-income and poor households could easily happen. Therefore the Chinese experts involved in this project recommend the extension of subsidies to low-income households. Detailed analysis is required to determine the extent of social assistance under various scenarios and how it can be financed. Any extension of social assistance for heating payments would further increase the financial challenges of local governments. A national transfer program should therefore be considered to mitigate the heating burden for urban residents in northern China.

Subsidy mechanisms generally provide support by lowering the heating expenses of poor households. They do very little to reduce consumption, even when the subsidy mechanism does not have a distorting impact. Measures to improve the tightness of the building shell lower the requirements for heating. Furthermore, traditional DH systems need to be supplemented with meters and controls, which enable consumers to control their consumption and their heating bills (see Box 2.13, with the Bulgaria example). Such measures are rather expensive, however, and unless very bad conditions are remedied, payback times of 5 to 10 years are typical; exterior insulation has an even longer payback time. These investments must be coupled with innovative financial instruments that enable consumers, particularly the poor, to distribute capital costs over a longer period and/or receive part of the necessary financing as a grant.[46] Actual programs to reduce energy waste in the homes of poor households—financed through existing social safety net efforts or other channels—are, however, very rare. One of the few examples is the heat subsidy in Lithuania (see Box 2.14).

Conclusions

A market-based, affordable, and equitable provision of heating services should combine full payment of heat bills by consumers and targeted financial support to poor and low-income households, as follows:

- Payment responsibility should be shifted fully to heat consumers.
- Targeted support to poor consumers needs to be reevaluated in the light of possible tariff increases. In particular, it should be considered to provide social assistance for payment of heating bills not only to *di bao*, but also to low-income consumers, which are not among the MLS beneficiaries.
- To preserve incentives for a rational use of heat, each consumer should pay at least some part of the heat bill. Alternatively, refunds for lower consumption could be considered.
- Introduction of flexible, customer-tailored payment terms to improve affordability and collection rates is especially important for lower income consumers.
- The use of subsidies to pay for metering and control equipment and some thermal renovation of existing buildings could lower heat expenses in the future.
- Financing of targeted social assistance needs a secure funding base. It should not be the responsibility of the heating company, but of the government, and the central government should share in the burden together with the local government.

A more efficient supply of heat, delivered by better managed and operated heating companies, and enforcement of energy efficiency standards for new housing construction and basic thermal renovation of existing buildings would reduce the amount and cost of heat to be supplied. Although this would benefit all consumers of heat, it would do so especially for poor and low-income consumers. Finally, metering and consumption-based billing provides an instrument to heat consumers to manage consumption and better adapt it to their needs and incomes.

[46] Lampietti/Meyer 2002.

5 Implementation of Heat Price Reform

Implementation Strategy: Actions and Sequencing

The Chinese experts/authorities list four important components of heat price reform:

1. Changing from invisible to visible heat subsidy with three subcomponents (i) transfer heat bill payment responsibility from the work unit to the consumer, (ii) establishment of a system of explicit cash payments for employees having benefited from welfare heating, and (iii) improvement of social safeguards for poor heat consumers;
2. Rationalizing the heat tariff by determining the justified costs and cost-recovery heat tariffs. This would support the commercialization and franchising of the heating sector;
3. Applying a two-part tariff, introducing metering and controls and transition from area-based to consumption-based billing; and
4. Improving the heat tariff management system.

Due to many required actions and in order not to jeopardize the success of the reform the implementation of these components should be carried out step by step. In their final report, Chinese national experts proposed implementation arrangements and requirements for heat price reform, which are summarized in Table 5.1. Actions to be implemented immediately and demonstration and pilot projects are proposed under all but the heat tariff management component. This acknowledges the urgency to get started and to gain experience with various alternative ways of implementing subcomponents.

Of the highest priority is the implementation of the market and social agenda in component one—that is, to make consumers responsible for payment of the heating bill, to provide some level of compensation for those consumers who received heat as part of in-kind wage payments, and to improve the social heat assistance system. The urgency of establishing a basic market relationship for the heating sector has been recognized by the central government in its December 2005 circular in which it gave a deadline of two years for transferring the responsibility for heat bill payments to consumers.

The main focus during the second phase, which should start in parallel to the first, would be the rationalization of the heat tariff, based on improved financial accounting and auditing of heating companies, to ensure that tariffs cover justified costs of heating. One of the suggested actions, the automatic linkage of heat tariffs and coal prices has already been introduced in late 2005. The national heat price management method has also been issued and will be in force starting October 2007, but further actions on the central and local government levels (e.g., development and enforcement of appropriate uniform accounting rules, rationalization of connection fees, clarification of asset base and valuation) are required to achieve the intended results.

The application of a two-part tariff system and transition to consumption-based billing is foreseen in the third phase. This seems to reflect the uneasiness of Chinese experts and practitioners with the results so far of heat

metering and consumption-based billing pilots, which have fallen somewhat short of expectations, in part since no metered tariff system was available. Based on cost-benefit considerations, the experts propose implementation of basic metering at the substation and building level before expanding metering to individual apartments.

The fourth component, improvement of the heat tariff management, is not restricted to a single phase. The experts emphasize the need to improve the management capacity of the government agencies responsible for heat price administration. They propose to continue the application of uniform tariffs in each city, but to differentiate tariffs according to the fuels used for heat generation. Improving the efficiency of the heating industry is an important objective of heat price reform and the experts propose nontariff measures, such as setting of efficiency targets for existing companies and for competitive bidding for new heating franchises.

Table 5.1 Heat Price Reform Components and Actions Proposed by Chinese Experts

Major Components	Subcomponents	Actions
First phase: Transform invisible to visible heat subsidy	Transfer heat bill payment responsibility to the consumer	• Criteria for compensation • Implement new billing system • Provide consumers with heat controls
	Social safeguards for poor households	• Surveys to determine gravity of heat poverty • Criteria for eligibility and subsidy level • Identification of financial resources
Second phase: Rationalize heat tariff	Determine justified costs	• Uniform financial accounting standards • Connection fee reform • Methodology for calculation of justified cost • Calculation of heat tariffs that recover total justified costs • Heat price adjustment formula • Definition of suppliers' and consumers' rights
Third phase: Implement two-part tariff	Transition from area-based to consumption-based billing	• Methodology to determine two-part tariffs under different metering arrangements • Guidelines for and implementation of metering (substation, buildings, individual) in new and existing buildings • Guidelines, financial arrangements, and implementation of retrofit of existing buildings, including for low-income households • Guidelines and implementation of room-level temperature control
Improve heat tariff management system		• Determine status and advancement of centralized heating industry • Determine and implement level of improved energy efficiency, particularly of DH companies

Source: Based on National Experts Team 2005.

Conclusions and Recommendations. It is obvious that the envisaged heat price reform requires radical changes, which need to be realized in several steps. This is recommended based on the experience from Eastern Europe, but also taking into account some issues particular to China:

- An increasing share of the income of private households whose employers currently still pay a large share of heating costs will likely be required in the near future to pay for heating. Although there is a strong intention on the political level to compensate households for their increasing contribution to heating costs, it is not clear to what extent consumers will receive payments, either from employers or social assistance programs. The reactions of consumers to out-of-pocket heating bill increases are hard to predict and must be monitored. The compensation payments will most likely mitigate, but not completely prevent some financial strain on household incomes.
- The proposed consumption-based billing system will induce consumers to take measures to adjust their heat consumption, including through investing in energy-efficiency measures. The extent of this adjustment process is hard to predict. It is expected that most consumers would be able to realize energy savings compared to the normative heat consumption. Experiences have to be collected about the magnitude of energy savings in different circumstances. Experiences from Eastern Europe show savings in the range of 10 to 30 percent (including savings from temperature-controlled substations).
- Consumers need to become familiar with the new control and regulation technologies. Although they will have more freedom and responsibilities to adapt the heat supply to their own needs, this requires an understanding of the way new technologies function and how behavior needs to change.
- Due to a lack of measurements of heat production, supply, and consumption, the actual final consumption is not known. Normative figures, which are based on the calculation of heat and ventilation losses, may substantially differ from actual consumption figures.
- Cost recovery requires the identification of the prudent costs of heat supply. Since too many different accounting systems are currently in use, many of which are incomplete, appropriate and uniform cost accounting standards and cost allocation systems need to be applied (designed if necessary) as soon as possible.
- Under the given circumstances, DH companies have difficulties preparing robust forecasts of costs, sales, and revenues. Overestimating the final consumption and, thereby, sales volumes (a frequent occurrence in Eastern Europe during the 1990s) could result in substantial financial losses. In addition to managing a technical modernization of heat supply, heating company managers therefore need to pay more attention to the business aspects of heating. If necessary, training has to be provided. The hiring of managers with business background should be considered.
- The local heating industries are very fragmented. The environmental, economic, and administrative performance of the sector would greatly improve if consolidation would be initiated and allow mergers of heating companies with fewer, cleaner and more efficient heating sources, lower overall personnel and overhead costs, more professional management, and simpler sector administration, including company-specific tariffs. Municipal heat planning would be a helpful tool in the restructuring of local heating sectors.
- Finally, estimates of required heating assistance program expenditures entail in-depth investigations of the likely number of affected households and their requirements for assistance. Sources of finance for such assistance will have to be identified.

Dividing the heat-price reform program into several phases would allow collecting experiences step by step and facilitate necessary

corrections. The proposal of the Chinese experts will help steer the heating sector from the welfare-based orientation to a more market-based operation. When comparing Table 5.1 to Table 1, the impression is that the experts' proposal lays out in most aspects how to move beyond a transitional stage. Only in some aspects it seems to fall short, particularly in how to incorporate better efficiency incentives for heat suppliers into the pricing system. Now the challenge is to proceed with implementation of heat pricing reform as part of overall heat reform to reap the full benefits of a market-based system.

Initial Implementation Experiences: Tianjin

The implementation of heat price reform in well-defined and sequenced actions is based on and backed to a large extent by the experience in Tianjin, which has been a pilot city for heat reform, including heat tariff reform, since the late 1990s. The heat price reform started with transferring the payment responsibility from work units to final consumers. This process was completed within three years, largely due to the fact that Tianjin has a relatively recent and modern heating infrastructure, a fairly high per-capita income, and relatively few problems with unemployment and poverty. Government employees are compensated through additional nonwage payments and poor households receive substantial discounts on the heat bill. Box 5.1 provides details of Tianjin's heat price reform experiences so far. Tianjin should continue to be a good pilot case for a deepening of heat price reform, since economic and social conditions are quite favorable, the heating period is relatively short and experiments with reforming the heating sector have been underway for some time.

Box 5.1 Experiences with Heat Price Reform in Tianjin

Tianjin is a municipality of provincial rank, 150 km southeast of Beijing, with about 10 million permanent inhabitants, of which about 6 million live in the urban areas. It has the highest per-capita income among large cities in northern China after Beijing and Dalian, while unemployment and poverty rates are among the lowest in northern China (for example, in 2003 only 3.7 percent of Tianjin's population participated in the MLS program, compared to 11.1 percent in Changchun, 9.4 percent in Harbin and 4.9 percent in Taiyuan; see Zhang/Xu 2005).

District heating started in Tianjin only in the 1980s and now covers about 80 percent of the urban residential floor area. The heating sector is still very fragmented, with more than 200 heating companies operating independent networks, many of them supplied from small coal-fired boilers. The municipal government is now implementing a 2003 to 2015 heat supply development plan, including the interconnection of the local systems, elimination of the small boilers, and development of larger heat sources that can provide heat with suitable environmental controls. This would be in compliance with the Tianjin "Blue Sky Program," which calls for the elimination of all coal-fired heating boilers of less than 7 MW and expanded use of DH and clean fuels within Tianjin's ring road.

As of 2005, Tianjin was the most advanced large city in China in the development of heat reform. Over a period of three years, starting in 2000, responsibility for heat bill payment was shifted completely from work units to households. Employers in the public sector are required to provide heating fee compensation as a nonwage benefit. Heat metering with different technologies has been applied in demonstration projects since 1997 (see Box 10). The strengthened enforcement of energy efficiency standards for new residential buildings has led to the best compliance record among northern Chinese cities in the country. In addition, Tianjin tightened the energy efficiency requirements for new residential buildings in a new standard in 2005.

As part of the ESMAP project "Heat Pricing and Billing Reform in China," Tianjin was chosen as the first case study for the development of a new tariff

Box 5.1 *Continued*

system. Local and national expert groups cooperated to design a practical tariff system based on the review of the operations of representative heating companies (see Box 2.3). The resulting two-part tariff covers, on average, the reasonable costs of heat supply in Tianjin, and includes taxes and a small profit margin. Heat tariffs continue to be uniform. Compared to the existing tariffs, the new tariffs are slightly higher due to increases in costs reflected in the tariffs. Variable and fixed part component have equal weight in the tariff, deviating slightly from the actual cost structure where variable costs have a 55 percent share. The Municipal Pricing Bureau has approved the methodology and the individual tariff components.

For the 2004 to 2005 heating season, after going through a formal tariff approval process, the Tianjin government raised the heat price for residential customers from 15.4 yuan/m^2 to 20 yuan/m^2. The tariff for nonresidential consumers was increased to a unified level of 26 yuan/m^2, from previously 18.5 yuan/m^2 for public, 21 yuan/m^2 for enterprises and 24 yuan/m^2 for hotels. All approved tariff increases are below the levels calculated according to the new heat-price methodology. At the same time, government employees received additional compensation for the heat price increases. *Di bao* continue to receive a 50 percent discount, while the local government will pay the remainder.

Starting in the 2005 to 2006 heating season, the two-part tariff was applied on an experimental basis for an area of two million m^2 in 12 residential communities. Residents were informed about this change by mail and published advertisements. All participating buildings comply with the 1995 building energy efficiency standard. The apartments are equipped with radiator valves and have either individual heat meters or heat cost allocators. Even though differences in heat consumption in the apartments of these new, well-insulated buildings should be fairly minimal (except for those triggered by the behavior of residents), simple compensating factors are used for calculating the heating bill.

Heat tariff and billing reform in Tianjin is part of the citywide heat reform plan to which Tianjin has committed as participant in the World Bank / GEF "Heat Reform and Building Energy Efficiency" project, which is currently under implementation. The project is also supporting several new housing projects in the application of both improved building energy efficiency standards and improved heat supply technologies.

Source: Based on Tianjin Experts Group 2003 and 2005.

6 Conclusions and Recommendations

Important Steps Forward toward Rational and Market-based Heat Pricing

The heat-pricing methodology developed under this project determines heat tariffs that are based on the full costs of the core heating business. This methodology can be used to calculate heat tariffs for unmetered customers, and it can be transformed into a two-part tariff to be used for consumption-based billing of metered customers.

The methodology for the determination of a two-part tariff was first developed for Tianjin and has been applied for additional case studies in Changchun, Harbin, and Taiyuan, and experts there accepted it for application. It has been broadly discussed and is recognized among national and municipal officials and other experts in the DH sector as an important step forward in heat-pricing reform. It is the basis for the 2007 national heat-pricing management method.

The partial automatic pass-through of coal price increases that came into force in 2005 is an important advance, since it limits the need for formal tariff reviews. This will contribute to securing sufficient financing of DH companies during periods of rapidly increasing input costs, providing a reasonable continuity and planning security and avoiding overt political influence over heat prices.

The experience from Eastern Europe clearly shows that heat-price reform needs to be packaged with a number of other measures, such as social assistance programs, heat cost reductions through efficiency improvements, installation of heat meters and consumer control devices, and consumption-based billing. Otherwise, tariff increases could easily trigger deteriorating collection rates and eventually nonpayment and even disconnections, offsetting the expected revenue increases through the adoption of heat tariffs that cover the full costs of heat supply.

The need to proceed with heat metering and consumption-based billing has been re-emphasized by the government. The minimum requirement of a meter at the building level is now widely accepted for new buildings. Metering and consumption-based billing demonstration pilots should become more meaningful with the application of a two-part tariff. This will provide a better basis for gathering information on actual performance of heating systems (i.e., heat losses) and on consumer behavior. Both are necessary to properly calibrate tariffs so that heat-supply costs are covered by sales revenues.

Establishing consumer responsibility for paying heat bills is an important ingredient in making the heat market work. The government has confirmed that this component of heat reform has to be in place by the end of 2007. The implementation of plans to replace employer-provided or paid-for heat services with explicit cash payment and to extend social programs to provide heat subsidies targeted at low-income consumers has started in many cities. With wider application of these programs, the probability of collection and affordability problems should be fairly low.

Applying this methodology is thus a first and important step to implementing a more rational heat-pricing system in northern Chinese cities. It can be considered an acceptable compromise

between continuing with the old heat-pricing system and a proper cost-related two-part tariff system. However, the methodology needs to be developed further in order to move from a transitional stage toward a fuller realization of the heat-reform objectives.

Many More Steps Are Necessary to Move beyond the Transition Phase

The proposed tariffs are uniform across a municipality and are based on a mix of adjusted average costs and standard costs of a sample of heat supply companies, rather than on the individual costs of a heat supply enterprise. Therefore, they cannot reflect cost differences in different heat supply enterprises due to differences in the management and performance of the heat supply enterprises, the use of different fuels (gas being scarce and much more expensive than coal), or different supply conditions. Until heating systems are more integrated into larger, more efficient systems and the number of heating companies is reduced from the hundreds to a more manageable number, the use of individual tariffs by heating company would be an almost impossible task to handle for the municipal authorities supervising the local heating industry. Also, the application of uniform cost accounting standards and a uniform tax treatment of all heating companies regardless of their ownership, would be requirements for heating-company specific tariffs.

Heat tariffs should cover the justified costs of heat supply to ensure that heating companies can cover their operating as well as their capital costs, including the replacement of assets. The cost of expanding heating systems is usually not covered by the tariff (with the exception of the profit component). In China, connection charges are common means in many cities to raise funds for financing of new heat supply infrastructure. Ultimately, consumers pay for this through the real estate they are buying. But in many cases, heat tariffs include the depreciation for the equipment financed through connection charges. Consumers would be charged twice in such cases. There is therefore an urgent need to clarify the legality of connection charges and to ensure that they are accounted for in a way that treats consumers fairly.

The proposed pricing methodology is based on historic costs of previous years. Since the newly determined tariffs will be applied in the future, tariffs should be based on the planned cost. This also requires a careful forecast of future heat demand.

The methodology does not provide any effective incentives or obligations for the heat supply enterprises to improve efficiency and performance. Tariffs are determined purely on a cost-plus basis. Profits are related to costs, thus providing an incentive to boost costs. Relating the profit to the invested capital (i.e., fixed assets and working capital) would improve incentives for efficiency, but the value of heating infrastructure assets is at best a very rough estimate. The use of competitive mechanisms to award concessions for heat supply areas, benchmarking of performance, and enforcement of efficiency standards would be nontariff measures to improve efficiencies. In the mid- to long-term, the use of incentive-based pricing with price caps would be preferable as a means to provide incentives for more efficient supply of heat (see page 100).

There is a consensus that a two-part heat tariff should be adopted. Provided the energy charge and the fixed charge are properly set, it can achieve a balance between financial security for the heat-supply company, which will prefer to minimize unpredictable variations in revenue, and the need to provide strong incentives for efficient use of energy. A two-part tariff with a capacity charge based on contracted maximum demand would also provide proper signals to consumers about the costs of capacity. For the time being it will, however, be related to the apartment area and thus not be able to provide the correct signals. Heat-supply companies should be allowed to adopt heat-load based capacity charges as soon as possible, particularly for new real estate developments.

Experts decided to give variable and fixed costs an equal share in the new heat tariffs, while in practice variable costs tend to be somewhat higher than fixed costs. In Western Europe a high variable tariff charge is usually applied to provide incentives to consumers to save energy, even though variable costs are fairly low due to the high capital intensity. In an economy such as in China where the behavior of consumers is widely unknown and not sufficiently analyzed, it would be risky to delink the tariff components from the actual cost structure. The two tariff components should follow the real cost structure as closely as possible, at least as long as consumer behavior is not known and consequences for the heat-supply company and consumers cannot be assessed properly. For similar reasons, it is not recommended to apply a one-part, energy-charge-only, heat tariff.

In a cost-based price-setting regime, the number of customer groups should be manageable, since each of the customer groups would have its own tariffs according to the costs they cause. It is recommended to use only one general customer group under a two-part tariff regime. Under such a tariff, different consumption levels (quantities) and different consumption patterns (even or uneven consumption over time) will result in different heating bills, even with the same tariff, provided the fixed part of the tariff is based on capacity (kW) rather than on area (m^2).

The lack of metering and metering experience in China has been cited as one reason for slow progress of heat price reform. The experience with and predominance of metered district heating in Western Europe and many Eastern European cities suggests that implementation of metering and consumption-based billing could be accelerated in China, particularly if meters were introduced in all new buildings, at least on the building level. If necessary, standards should be prepared and their implementation monitored and enforced. It should be considered that heating companies can refuse to connect new buildings without meters to the heating network. For older buildings, metering at the building level is not an insurmountable problem either, but as the experiences in Eastern Europe and in some pilot projects in China (for example, Baotou) have shown, technical problems such as water quality and reliability of meters need to be resolved. Admittedly, the issue of how to fairly implement consumption-based billing in poorly insulated buildings remains contentious. Evaluating the results of heat metering would contribute to a better understanding of the actual heat demand and factors affecting demand and would be helpful in coming up with innovative schemes for consumption-based billing in existing buildings.

The tariff setting and approval mechanism currently involves many different steps, requires several municipal agencies to collaborate and sign off, and requires public hearings, and in the end the municipal government makes a decision. This process needs to be streamlined further to ensure that tariffs and the tariff-setting process are simple and transparent in order to make the process manageable and to increase the acceptance of tariff changes by consumers, politicians, and the regulated companies. In the longer term, more professional and independent heat regulation agencies should be established. The use of a hybrid price cap mechanism under which tariffs would be approved for a period of three to five years, including the application of a price adjustment formula, should also be considered.

Equity issues need to be continuously monitored and addressed during heat reform. For poorer households, heat bills already constitute a much larger share of income than for households with higher incomes. This is not a large problem under the traditional system with many employers paying for their employees or the government paying for *di bao*. However, some poor without employment, but not qualifying for MLS payments, are confronted with heat bills they cannot afford. With the transfer of the invisible to a transparent subsidy under the ongoing heat reform and responsibility of households for payment, the problem of an unsustainable heat-bill burden for low-income households becomes larger and very visible.

Therefore, workable targeted subsidy mechanisms including low-income households

need to be devised or improved upon. In particular,

- Targeted support to poor consumers needs to be reevaluated in the light of possible tariff increases.
- To preserve incentives for a rational use of heat, each consumer should pay at least some part of the heat bill.
- Introduction of flexible, customer-tailored payment terms to improve affordability and collection rates is especially important for lower-income consumers.
- The use of subsidies to pay for metering, controls and some thermal renovation of existing buildings could lower heat expenses in the future.
- Financing of targeted social assistance needs a secure funding base; it should be the responsibility of the government, not of heating companies.

A more efficient supply of heat, delivered by better managed and operated heating companies, and enforcement of energy-efficiency standards for new housing construction and basic thermal renovation of existing buildings would reduce the amount and costs of heat to be supplied. Although this would benefit all consumers of heat, it would do so especially for poor and low-income consumers. Finally, metering and consumption-based billing would allow households to further reduce their heating bills and adapt heating expenditures to their incomes.

The introduction of heat-pricing reform should be carried out in a carefully planned sequence to avoid surprises and frequent changes in the beginning due to the lack of information. For example, actual losses in various parts of the heat-supply system, the real consumption in various types of buildings (old and new), and the reactions of consumers to consumption-based billing are typically unknown in the beginning. This makes any permanent decisions and the prediction of what will happen to consumers' bills and heating company revenues very difficult. Metering, monitoring, and evaluation of pilot projects with consumption-based billing, and information and education of consumers should precede widespread introduction of consumption-based billing. The sequencing would also allow resolving technical problems that are bound to happen when metering and control equipment is used in larger numbers.

Steps Needed to Achieve the Expected Results and Impacts

A wider application of consumption-based tariff systems is important since it will contribute to a substantial reduction of coal consumption and emissions. Experiences from Western and Eastern Europe show that consumer control and metering of heat consumption and consumption-based billing will typically result in a reduction of heat demand by some 10 to 30 percent. Much of this can be achieved with metering at the building level, which should be widely and quickly implemented as a minimum requirement.

Consumption-based billing will also provide incentives for consumers to buy better, more energy-efficient apartments that are supplied by more efficient heating systems. The overall impact of a package of heat price reform and improved building energy efficiency with a growing building stock is several times larger than that of consumption-based billing in isolation and is estimated to reduce coal consumption for heating and associated CO_2 emissions by at least one third (see Figure 1.3).

Heat suppliers will ultimately benefit from those changes as well, even if heat consumption goes down, leading to reduced sales and revenues in the short term. In the mid- to long-term they can generate profits again by modernization investments thus improving efficiency and reducing costs of heat provision and by connecting new customers to the network. For Chinese heating companies the impacts of heat metering and consumption-based billing could turn out to be much more beneficial since new housing developments and thus new customers are materializing every day. With heat loads and consumption of existing

customers decreasing, new capacity and supply does not have to be provided completely from new infrastructure, provided that local heat markets are restructured in a way that gives companies and existing infrastructure a chance to supply new housing developments.

Moving from the Transition Phase to Real Heat Price Reform

The implementation of the proposed first steps of heat price and billing reform is taking place in an environment that is still largely shaped by the legacy of welfare heating:

- A large number of heating companies exist in many cities, with owners ranging from the municipality proper, the power sector, to real estate bureaus. They all operate under different legal, tax, and accounting rules. Assets of heating companies are not well defined, and their book values may not reflect replacement values.
- Heating infrastructure is still largely financed by customers through connection charges. What used to be the role of work units has been taken over by real estate developers and ultimately by consumers.
- Municipalities have conflicting roles as owners of heating companies and regulators of the local heating industry.
- Consumers in established DH systems in large cities are just now becoming responsible for payment of heating bills, and they may or may not be compensated by employers or receive social assistance if they are poor.
- Heating companies and consumers have relatively brief and limited experiences with heat metering, consumption-based billing, and consumer control of heating consumption. Most heating companies still bill their customers based on heated area. Actual losses in heating systems and actual consumption of different types of buildings are still largely unknown.

As long as those conditions are not changing, heat price reform will remain in a transitional state, and the expected results will not be achieved. Therefore, obstacles that prevent the actors in the heating sector from overcoming the welfare-based way of doing business need to be removed. Among the most important changes to be introduced as soon as possible are as follows:

- Uniform rules of doing business should be applied, including accounting framework and taxation.
- Local heating sectors should be consolidated, taking into account municipal heat plans carried out with regard to least cost and environmental considerations.
- Heating companies should be licensed to ensure that they are technically and financially able to operate a sound and efficient business.
- Metering of customers should be completed, at minimum at the building level. A consumption-based bill must be distributed at the building level among all inhabitants in a variety of ways.
- Heating companies should be commercialized, including separating municipal ownership from regulation and supervision. Heating infrastructure assets need to be clearly assigned and valued properly.
- Improvements should be made in the knowledge base about and within the centralized heating sector through extended data gathering as part of regular statistical surveys, analysis of metering data, customer surveys, and benchmarking of heating company operations, within and across municipalities. This also requires more professional regulatory agencies on the national, but especially on the local levels.

It is proposed to move forward quickly in all areas, establishing the basis for the introduction of heat pricing rules that offer more and better incentives to suppliers and consumers to provide and use heat efficiently:

- *Company-specific heating tariffs*. Among the most important advances to be made is the transition from uniform citywide to

company-specific heating tariffs. Tariffs based on the individual costs of a heat supply enterprise cover the justified costs of individual suppliers and reflect cost differences due to differences in the management and performance of the heat supply enterprises, the use of different fuels or different supply conditions. Thus, heat suppliers would be able to cover their operating as well as their capital costs, including the replacement of assets.

- *Profit margins based on asset value are particularly important with company-specific heating tariffs.* Under the alternative of cost-based profits it would be even harder to control the incentive for companies to inflate costs.
- *Two-part tariffs with fixed charges based on capacity instead of square meters would provide incentives to customers to properly determine required heat demand*. Such properly designed two-part tariffs would also be able to reflect the different costs of customers with different consumption levels and patterns.
- *Introduction of incentive-based pricing under which properly designed base heat tariffs would be in force for three to five years with automatic pass-through of the most important cost components*. This would provide better incentives for heating companies for efficiency improvements than cost-of service pricing as proposed for the transition phase.

By moving forward in all areas, heat price reform can join other areas of heat reform to realize the expected benefits of substantially reduced coal consumption and improved urban environments, lower heat bills and more comfort for consumers and a heating industry which becomes a tax payer instead of requiring periodic injections of public funds.

Annex Glossary of Heating Technical Terms

(Unless mentioned otherwise, the source is ESMAP 2000)

District Heating

Usually, the term *district heating* (DH) describes a system supplying heat produced centrally in one or several locations to a nonrestricted number of customers. Heat is distributed by means of a network using pressurized hot water or steam as a medium. Often, the heat is also used for domestic hot water preparation (though rarely in China) and for industrial purposes, such as process heat. Although most people understand DH to be large centralized urban heating systems, many national statistics also include very small heating systems. In the case of China, the term DH is reserved for centralized heating systems with capacities greater than 10 tons/h, sufficient to supply approximately 100,000 square meters of construction.

A DH system (see Figure A.1) consists of heat generation plants, CHP plants and HOBs, transmission or primary networks between generation facilities and substations and distribution or secondary networks between substations and buildings. In modern DH systems substations often are located in buildings, eliminating the need for a distribution network.

Cogeneration or Combined Heat and Power

Compared to separate production of heat and power in HOBs and condensing power plants, respectively, the same amounts of heat and power can be produced in CHP plants using about one-third less fuel. The exact savings depend on the types of power and heat plants, the cogeneration technology, and types of fuel used. The energy savings of cogeneration can be illustrated in a *Sankey diagram* (see Figure A.2), which depicts the fuel inputs, sources of losses, and outputs of power and heat for separate and joint production. To generate 55 units of electricity and 100 units of heat, the fuel consumption in the CHP case (176 units) is 31 percent less than in the separate generation case (256 units). The values in Figure A.2 are typical for cogeneration technologies based on the use of solid fuels currently used in Western Europe.

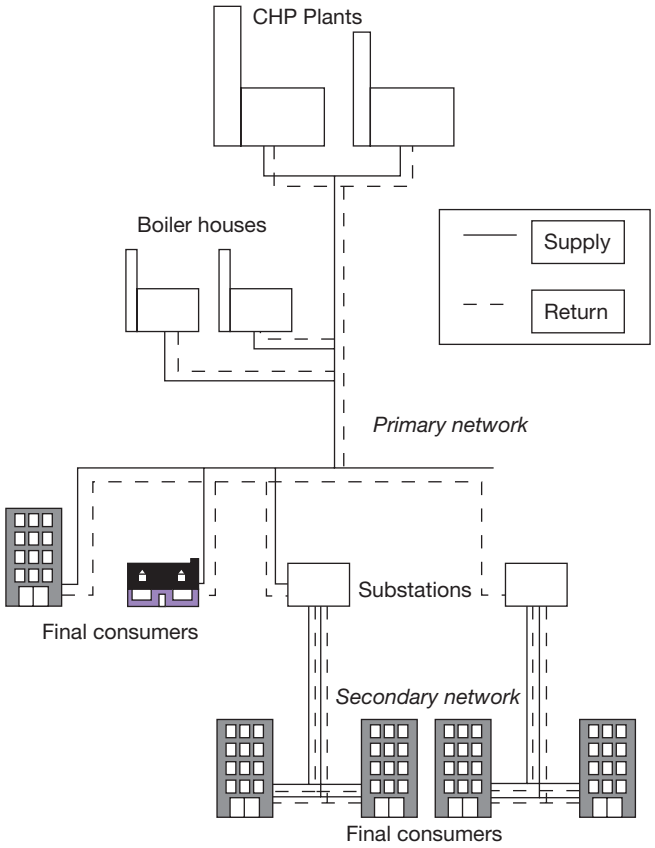
Mode of Operation: Constant Flow and Variable Flow

There are two distinct models for designing and operating a DH network:[47]

Constant flow is the quality control referring to supply temperature regulation. The water flow

[47] The terms *variable/constant flow control* are used in Western literature, and *quantity/quality control* in Eastern literature.

Figure A.1 Schematic View of Typical District Heating System in China



Source: ESMAP 2000.

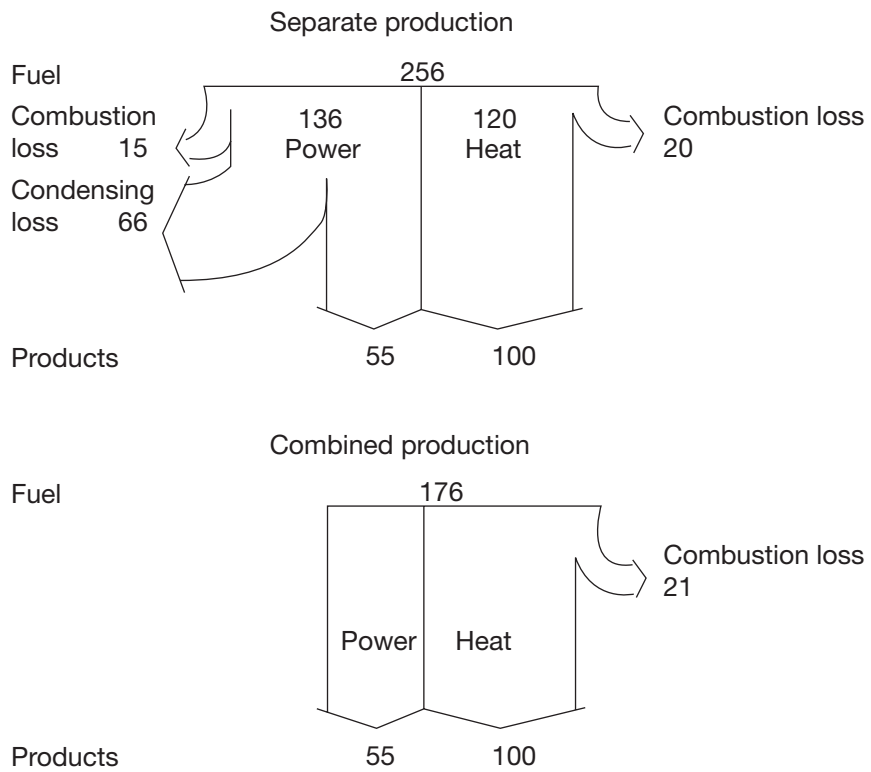
is kept constant whilst the supply temperature at the heat source is varied according to outdoor temperature to match the system output with expected heating need. This mode does not require flow regulation equipment. In other words, the heat source regulates how much heat will be delivered to the consumer.

Variable flow is quantity control referring to water-flow regulation. Both the supply temperature and the water flow are varied according to outdoor temperature to match the system output with the real heating need. This mode requires flow regulation valves at points of consumption. The circulation pumps at heat sources are usually equipped with speed controls to save electricity in variable flow systems. In other words, heat consumers regulate how much heat they really need and the heat source has to adjust the supply temperature according to the outdoor temperature.

The use of constant flow technology does not require advanced technology and is quite robust and easy to implement. It has a number of disadvantages:

- More heat energy than necessary is sent through the system. The concept of constant flow means that the distribution of energy is determined by a number of fixed valves, orifices or other throttling equipment in the system, which are set manually every now and then. The heat production plant via its setting of temperature of the supply water determines the heat output for each radiator. Because of imbalances in the system, some customers receive more and others less heat than needed. Especially in spring and autumn, the supply temperature of the primary system must be higher than needed for space heating needs in order

Figure A.2 Energy Balance of Separate and Cogeneration of Power and Heat (for Solid Fuels)



Source: ESMAP 2000.

to maintain the DHW temperature at an acceptable level. This causes high space-heating temperatures, resulting in excess room heat that must be ventilated out through open windows. The annual average temperature in the piping system (supply and return water temperatures) is lower in the variable flow system than in the constant flow system leading to lower heat losses and higher power production at CHP plants.

- Since consumers cannot control their heat intake, the constant flow system makes it impossible to achieve the full benefits of a modern, incentive-based system of heat supply and demand.
- Pumping costs are higher. In constant flow systems, electricity consumption for the secondary network in relation to the heat supply ranges between 12 and 20 kWh/MWh (used electricity/supplied heat); in variable flow systems, the value is 5 to 8 kWh/MWh. However, some of the higher electricity consumption benefits the heating system, as friction heat is passed on to the DH water.
- There is a higher need for heat production capacity. Due to the constant flow design, the coincidence factor of peak demand is close to one. In a variable flow system the coincidence factor of peak demand is 0.6 to 0.8, and therefore the capacity of the heat sources can be 30 to 40 percent less.[48]
- Variable flow allows for a lower temperature in the system at peak demand, which again

[48] Even after switching to variable flow, DH systems in Central and Eastern Europe will not achieve a coincidence factor of demand as low as 0.5 to 0.6. In Western Europe, the coincidence factor is low because of the important share of residential consumers in individual houses, and because of the prevalence of two string radiator systems with thermostatic valves. In Central and Eastern Europe, single family houses make up an insignificant proportion of heat demand and many high rise buildings have one-string radiator systems. This reduces demand variations. The situation in China is initially closer to the latter, but with the quick adoption of modern technologies in new housing developments coincidence factors closer to the Western European one should be achievable.

makes it possible to increase electricity production at the CHP plant.

- Constant flow does not allow for merit order dispatching of heat plants along the transmission system. Load dispatching (including from decentrally located alternative supply sources) is not possible without manual isolation of specific supply areas. It means that the capability of adapting to changes in demand and production is very limited. Variable flow permits the establishment of peak and reserve load boilers in the local supply areas and dispatching of the plants according to merit order.
- Constant flow requires slow-flow velocities and respectively larger pipes (otherwise, the pumping cost would be very high), which leads to higher investment cost. Variable flow can provide the same heating capacity with use of smaller diameters. In variable flow, the velocities in the pipes can be twice as high as in a constant flow system for the short time when the maximum transmission capacity is really needed. However, because the higher transport capacity of variable flow is used to lower the maximum temperatures in the system, the difference in diameter sizes is relatively small in practice.

Transition from constant to variable flow: When customer installations are equipped with controls that regulate the water flow, the system turns from the constant to the variable flow operation mode. In a typical DH system with thousands of consumer substations, several years are required to implement the transition process. The basic problem in the transition phase is how to organize the mixed constant/variable flow operation when one part of the substations regulates the flow and the others do not. If the transition is not properly organized, the constant flow customers will suffer underheating in winter and overheating in spring and autumn. To prevent inconveniences, the rehabilitation should take place branch by branch. As one main network branch is rehabilitated, the other mains have to be equipped with pressure difference control valves which keep the pressure difference constant for the old fashioned customers of the branch to enable them to function as they used to.

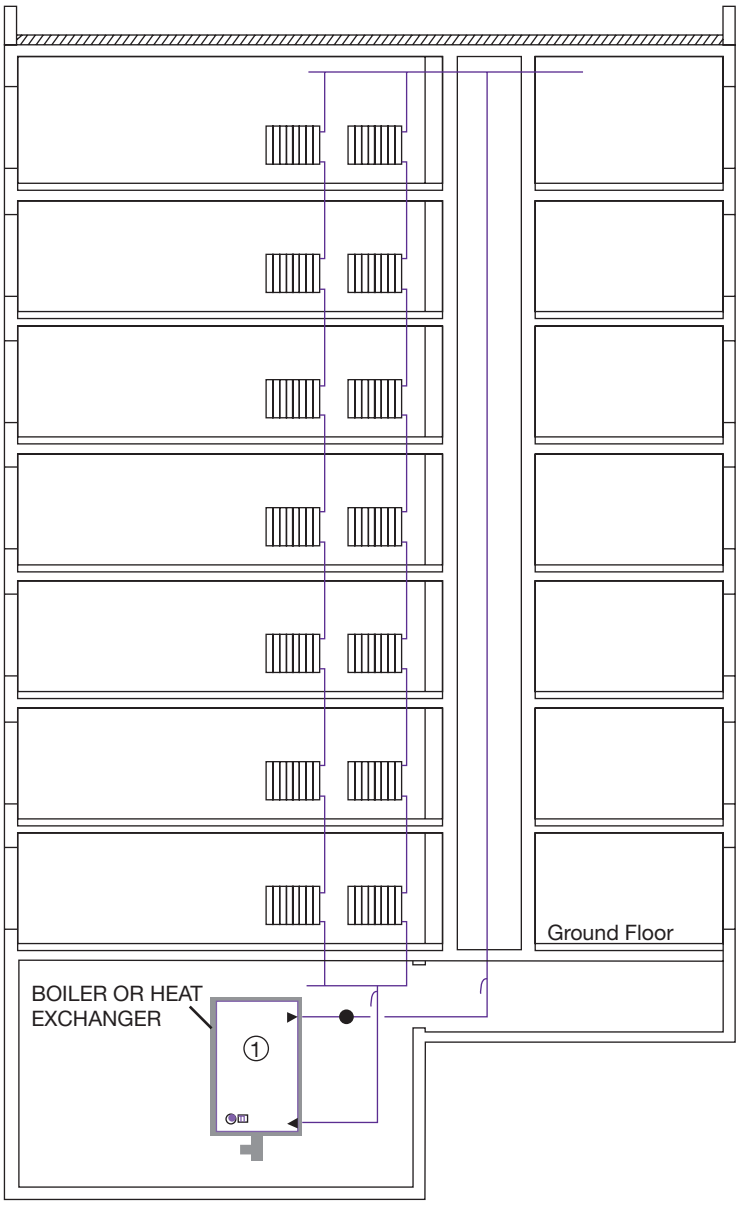
Indirect and Direct Connection and Vertical and Horizontal Building-Internal Piping

In *direct systems,* the primary pipe network (from the heat production plant to the central substation) and the secondary network (from the central substation to the heat receiving stations in the buildings) are directly connected by valve devices. Also, the secondary network and the building heat distribution system are directly connected at the building substation (without heat exchangers), where mixing pumps and valves or hydro-elevators are applied. In *indirect systems,* heat exchangers are used, isolating the primary from the secondary space heating networks.

Unlike in most buildings in Western Europe, radiators traditionally installed in buildings in Eastern Europe or in China are not connected in parallel (Figure A.4), but in series (Figure A.3). Radiators are *vertically* connected to each other. From the substation a distribution ring is installed in the basement, from which risers go up to the top level and are connected to the top radiators of the vertical strings. The bottom radiators of the strings are connected to a collector pipe in the basement. Such system is referred to as a one-pipe system, instead of the two-pipes, which are connected to each radiator when radiators are installed in *parallel*.

One consequence of the one-pipe system is that the entrance temperature to each following radiator is lower than that of the previous one. In the design, the drop in temperature from one radiator to the next is compensated for by increasing the radiator area. A second consequence is that an apartment is crossed by several vertical strings. Thus, measuring the heat consumption for one apartment requires measuring the contribution of each radiator supplied by a separate string. Introduction of heat control at the level of a radiator is also more

Figure A.3 Building Internal Heat Distribution: One Pipe Vertical Risers Connected in Series



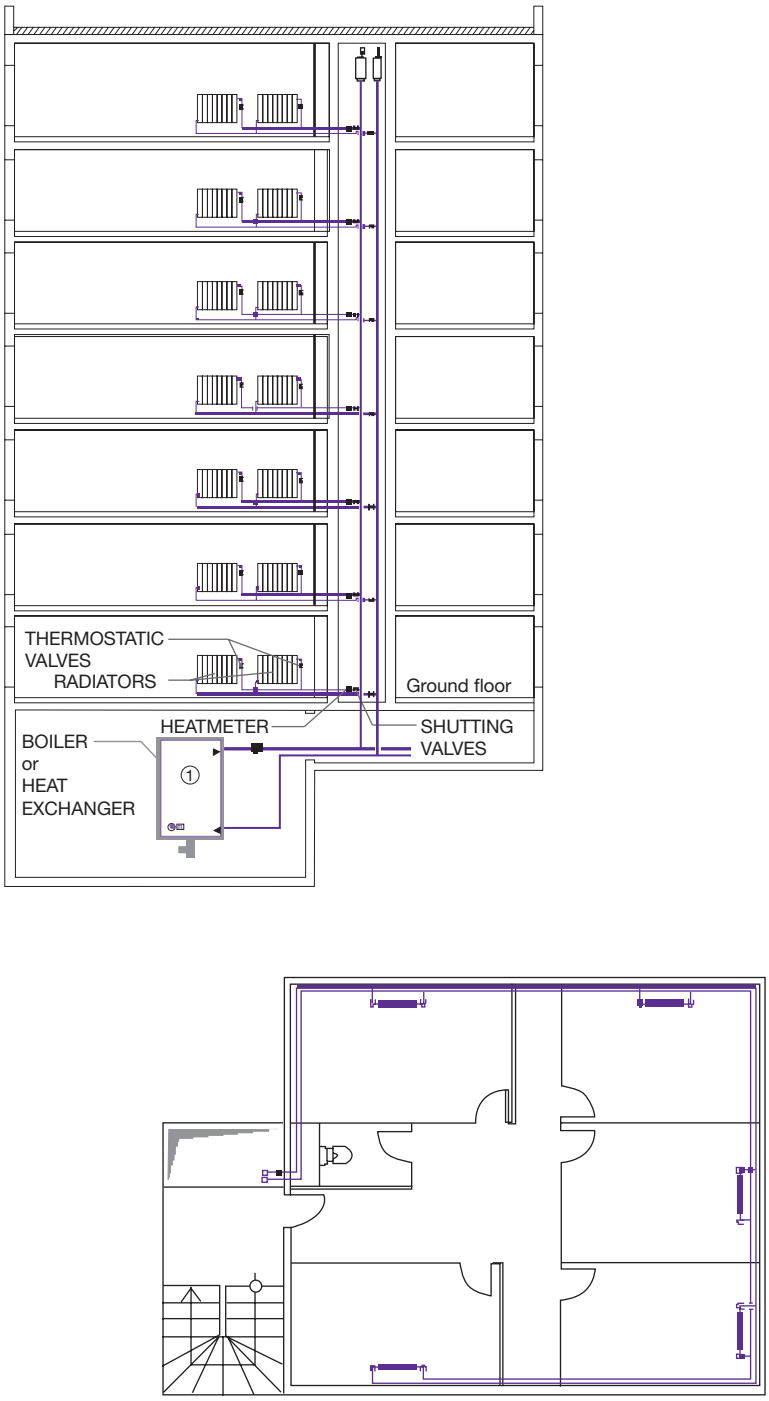
Source: Marc Bellanger (SOREIB).

complicated. Thermostatic valves must have low resistance and bypasses must be installed to allow continuation of the flow to the next radiators when the valve is closed.

In many buildings in Eastern Europe and China, the internal heating system is unbalanced, meaning that the division of the flow amongst the individual risers is poor—some risers receiving too much, others too little water. By installation of balancing valves in each string, the situation can be improved. However, the consequence of such measures is that it increases the required pressure drop between the supply of the risers and the return in the collectors.

In more modern buildings, in Western Europe, but also in new buildings in Eastern Europe or in China, radiators within an apartment are installed in a *horizontal* loop (see

Figure A.4 Building Internal Heat Distribution: Horizontal Distribution with a Two-pipe System



Source: Marc Bellanger (SOREIB).

Figure A.4). A central riser is installed in each staircase from which branches extend into each apartment, looping back to the central return pipe in the staircase. This configuration allows a more even heat distribution and enables apartment-based control and metering.

In some cities in China—for example, in Shenyang and Changchun—the building-internal piping in older buildings has been reconfigured to horizontal piping, with a shut-off valve and space for a heat meter for each apartment located in the staircase. This measure was implemented not so much to enable metering and consumer control and consumption-based billing, but to improve collections by being able to more effectively cut off individual consumers. The cost-benefit of this conversion to horizontal piping is dubious at best.

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List of Formal Reports

Region/Country	Activity/Report Title	Date	Number
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	—
	Francophone Household Energy Workshop (French)	08/89	—
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	—
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
	Commercialization of Marginal Gas Fields (English)	12/97	201/97
	Commercializing Natural Gas: Lessons from the Seminar in Nairobi for Sub-Saharan Africa and Beyond	01/00	225/00
	Africa Gas Initiative—Main Report: Volume I	02/01	240/01
	First World Bank Workshop on the Petroleum Products Sector in Sub-Saharan Africa	09/01	245/01
	Ministerial Workshop on Women in Energy	10/01	250/01
	and Poverty Reduction: Proceedings from a Multi-Sector	03/03	266/03
	and Multi-Stakeholder Workshop Addis Ababa, Ethiopia, October 23–25, 2002		
	Opportunities for Power Trade in the Nile Basin: Final Scoping Study	01/04	277/04
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