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CHINA: OPPORTUNITIES TO IMPROVE ENERGY EFFICIENCY IN BUILDINGS

Asia Alternative Energy Programme and
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FOREWORD

Substantial results in efforts to improve the energy efficiency of space conditioning in urban residential and commercial buildings in China are slow in coming. The use of highly energy inefficient designs, materials and construction is continuing unabated through the construction boom since 1990. More than one-half of China's urban residential and commercial building stock in 2015 is expected to be constructed after the year 2000. Demand for heating and cooling service in the new buildings will be greater than ever. Most unfortunately, almost all of the new buildings being constructed are still based on the older, highly energy-inefficient design principles. Central heating systems are still mostly based on designs from the 1950s that allow no consumer adjustment of heat levels.

This study was, therefore, undertaken to establish priorities for supporting measures to improve the energy efficiency of Chinese residential and commercial buildings, and to help lay a foundation for future support by international donors, especially the Global Environment Facility (GEF). Whereas the former housing construction, ownership and occupation system stymied efforts to improve building energy efficiency in China for many years, institutional and incentive changes from ongoing housing reforms present major new opportunities for energy efficiency gains.

The study concludes that major cost and energy savings can be achieved in urban residential heating supply and use systems, with major benefits for peoples' livelihood, environment and financial performance of heat companies. Achievement of meaningful savings however, will require a "two-hand" approach, combining both reform of the heat billing and metering system, and associated heat supply system modernization, together with more aggressive development of more energy efficient buildings.

It is expected that such a "dual track" approach could be implemented in several more innovative municipalities, as a core element in a future GEF/Bank investment project. As a result of the study the development and implementation of a range of related, high-priority technical assistance activities is also being pursued.

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The leading options to overcome the outstanding policy and institutional barriers blocking progress in promoting more energy efficient buildings, especially new buildings, were discussed at a major workshop in Beijing during March 6-8, 2000 with about 40 experts from a variety of Chinese agencies and institutes and several international groups.

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ABBREVIATIONS AND ACRONYMS

DOE	Department of Energy
ESCO	Energy Service Company
GHG	Greenhouse gas
HVAC	Heating, Ventilation, Air Conditioning
MOC	Ministry of Construction
NUTEK	Swedish National Board for Industrial and Technical Development
OWMR	Office of Wall Materials Renovation
PVC	Polyvinylchloride
SPV	Swedish Building Code Agency
TRV	Thermostatic radiator valve

UNITS OF MEASURE

Gcal	Gigacalorie (one million kilocalories)
GJ	Gigajoule
K	Kelvin (0 K = -273.15 Celsius = -450 Fahrenheit)
MWh	Megawatt-hour
M^2	Square meter
Rc	Thermal resistance value
TCE	Ton of raw coal
TWh	Terawatt-hour
W	Watt

ENERGY UNIT CONVERSION

1 Gcal	= 1.16 MWh = 4.19 GJ = 1.75 steam tons/hour
1 GJ	= 0.278 MWh = 0.239 Gcal = 0.42 steam tons/hour
1 MW	= 0.86 Gcal = 3.6 GJ = 1.52 steam tons/hour
1 TCE	= 5 Gcal = 20.9 GJ = 5.8 MWh

CURRENCY EQUIVALENT

US$ 1 = RMB 8.28 (2000 average)

EXECUTIVE SUMMARY

Why promote more energy efficient buildings? China has not yet achieved substantial results in efforts to improve the energy efficiency of space conditioning in urban residential and commercial buildings. Residential buildings in China are estimated to consume 50-100% more energy for space heating as compared to buildings in similar cold climates in Western Europe or North America, and still provide far less comfort. The major reasons are heat losses through exterior walls, through windows and through imbalances and inability to control heat use in centralized heating systems, and a series of maintenance and management deficiencies stemming from the current heat billing system.

The most critical aspect of China's building energy waste problem is that the use of highly energy inefficient designs, materials and construction is continuing unabated through the construction boom since 1990. More than one-half of China's urban residential and commercial building stock in 2015 is expected to be constructed after the year 2000. Demand for heating and cooling service in the new buildings will be greater than ever. Most unfortunately, almost all of the new buildings being constructed are still based on the older, highly energy-inefficient design principles. Central heating systems are still based on designs from the 1950s which allow no consumer adjustment of heat levels.

The Chinese Government has promulgated new energy efficiency standards for buildings in the heating zone, aimed to achieve energy savings in new buildings of 50% compared to buildings constructed in the early 1980s, but the standards are generally not enforced. Solid progress has been made in developing more efficient building designs suitable for Chinese conditions, and various more energy-efficient windows, building materials, insulation board, etc., demonstrated in a number of pilot project efforts. But without enforcement of the building standards and changes in the prevailing heat billing system, neither the building design and construction industry, nor building owners and users, have the incentive to make the major changes necessary in heated buildings to move from pilot efforts to real implementation.

Urban space heating has been considered a government-sponsored welfare requirement in northeast, northern and northwestern China for decades. But the sharp economic downturn in Northeast China during the late 1990s, coupled with the great inefficiencies of the heating supply and use systems, has created a financial crisis for these heating systems. According to official estimates, in the three northeast provinces bills for heat supply at current prices are equivalent to 15-30% of individual household incomes. Fundamental resolution of these problems will take time and requires simultaneous action on a series of difficult fronts, including (a) reform of the heat billing system to make end-users accountable for heat bills calculated based on actual heat consumption, in line with other ongoing housing and state-owned-enterprise reforms; (b) adoption of methods to increase end-user control of their heat usage; (c) measures to improve end-user heating comfort levels and reduce end-user costs by improving the efficiency of heat use by end-users; (d) investment and operational/management reforms in heat supply companies to reduce inefficiencies and costs.

Improvements in efficiency can substantially reduce current high environmental costs associated with space conditioning, especially heating, by reducing the very high local particulate and sulfur dioxide concentrations typical of Chinese cities in the heating zone as well as the global greenhouse gas (GHG) emissions resulting from coal use for heating purposes.

Attaining real results in improving the efficiency of space conditioning in buildings is a long-term proposition, but progress requires concrete actions to be taken now, in order to make a difference. Serious action during the next 1-2 years on a number of the difficult problems constraining progress is urgent because:

- Every year lost in developing more efficient buildings locks in some 700-800 million square meters of urban residential and commercial building floor area with inordinately inefficient energy use for future decades.

- China's recent and continuing implementation of major housing reforms offer the opportunity to align end-user incentives in support of more efficient energy use in residential buildings. As families, as opposed to work units, buy and own their homes, their attention to heating and cooling comfort, and their interest in minimizing utility costs, can provide a powerful market-based lever for improving building energy efficiency if supporting policies and programs are put in place.

- Improving the end-use efficiency of heating in buildings is one of the key measures necessary to alleviate the current financial crisis facing the municipal heating systems in northern China. Reforms in the configuration and billing systems for home heating also serve both ends—they are of central importance for improving both the technical and financial position of the heating companies, and the efficiency of heating energy end-use.

The Need for a "Two-Handed" Approach in Improving Building Energy Efficiency in the Heating Zone. To realize better results in efforts to improve energy efficiency in urban buildings in the heating zone will require a more comprehensive approach, encompassing both reform of heat system control and billing, and strong efforts to systematically implement building energy efficiency standards.

On the "left hand", policies and programs must be implemented which make heat a commodity—to enable consumers to be able to control how much they consume, and pay according to actual consumption. Only then will consumers have incentives to use heat wisely, and realize the benefits which can be obtained from more efficient use. There are four, interrelated necessary reforms:

(a) Adoption of technical measures to allow consumers to control their heat consumption. For new systems, this requires a variable-flow, two-pipe design, and use of manual valves or thermostatic radiator valves (TRVs). Horizontal pipe configurations for each apartment work best. Existing constant-flow, vertical, single-pipe systems can be retrofitted to allow consumer control by adding control valves, radiator by-pass pipes, and making adjustments at the building/substation level to accommodate the flow variations.

(b) Adoption of some means to determine actual heat consumption and allow billing accordingly. The minimum requirement is for centralized heat use at the building or apartment complex level to be metered and billed. This should be implemented as soon as possible. New buildings should be constructed with horizontal/dual pipe systems, which entail virtually no extra cost, but allow apartment-level supply and cut-off flexibility, and apartment-level metering at any desired time in the future.

(c) Reform in the bill payment system, so that individuals pay for their heat use, rather than their employers or the state. Where low-income families require financial support for being able to afford basic heating needs, this can and should be efficiently provided through the government.

(d) Reform of heat tariffs, so that heat is billed according to actual use (gcal), as opposed to heated area (square meters). This is necessary to provide incentives for consumers to use heat efficiently. A two-part tariff is recommended, similar in many ways to the common electricity tariff for large industrial customers, including: (i) a capacity charge, based on heated square meters or contracted maximum demand (eg. Gcal/hour), designed to defray at least a large portion of the costs of fixed assets of heat supply companies, and (ii) an energy charge, based on Gcal consumed per billing cycle.

Broad international experience has shown that by themselves the incentives triggered by the "left hand" reforms are not enough to cause the full potential for cost-effective energy efficiency improvements in new buildings to be realized. The power of individual consumer interest alone is not enough to cause the major changes needed in the building development industry, which encompasses a range of diverse actors. This is why virtually every country with major heating requirements in buildings has adopted some form of mandatory building energy efficiency standards.

On the "right hand" therefore, policies and programs must be implemented in China to ensure that the existing energy efficiency building standards are more effectively adopted in practice. Widespread adoption of more energy efficient designs, materials and construction methods requires some basic changes in customary practices by a large number of different actors, and hence, a major organizational effort. Where and when the political will for such changes is present at the city level, at least three key measures are required:

(a) Mechanisms to ensure that implementation of the energy efficiency standards becomes an integral and regular part of the general building code inspection and enforcement system.

(b) Model designs and specifications, and detailed regulations, must be developed and issued for those key aspects of building and heat system design and construction where changes are critical, and professionals working on building design and construction management must be trained in the new methods.

(c) Information dissemination and other programs to help spur the rapid, market-based development of new, more energy efficient building material products and technical approaches (such as testing and certification or organization of large-scale procurement packages) need to be implemented.

Since major improvements in the energy efficiency of existing buildings (excluding heat supply systems) are generally not very cost-effective (i.e., payback of investment of more than 10 years), efforts should concentrate on new buildings.

Building energy efficiency outside of the Heating Zone. Until the 1990s, in the "Hot Summer, Cool Winter Region" of central and eastern China the combination of cold and humid indoor conditions in winter, due to lack of heating, and hot indoor temperatures in summer, meant that indoor living conditions were far less comfortable than further north. During the last decade or so, as incomes have risen, sales and installation of electric resistance heaters, electric heat radiators, air conditioners, electric hot water heaters and heat pumps have boomed. Modern commercial buildings are all adopting space conditioning systems. However, this massive increase in space heating and cooling has occurred in a haphazard way which wastes a lot of energy and money. Also, the building design and construction industry in many cases is still producing new buildings which are difficult to keep comfortable at reasonable cost.

Consumers in the non-heating zone must pay the costs of any space heating or cooling themselves. The fuels used, particularly electricity, are well monetized, and payments linked to actual use. Energy prices generally conform with supply costs. Therefore, market forces can play a larger role in the promotion of energy efficiency in the non-heating zone. Market forces *cannot*, however, be relied upon exclusively to foster the wider range of cost-effective energy efficiency improvements which are possible and clearly in the long-term public interest.

Efforts are currently underway to design and implement building energy efficiency standards for the Hot Summer, Cool Winter Region. Especially important aspects of this work include the effort to institute energy efficiency requirements for new cooling, heating and HVAC equipment, and the establishment of benchmarks concerning the thermal performance of building envelopes. Improving the energy efficiency of heating and cooling devices is clearly an effective way to save energy and to reduce peak power demand. This includes adoption of higher efficiency models of common window or split-unit air conditioners, as well as expanded adoption of heat pumps, which are just becoming popular on the Chinese market. A minimum level of public intervention is to implement government-sponsored programs to subject different models on the market to standard energy efficiency tests, followed by restriction of the most energy-inefficient models and/or requiring standardized, government-endorsed labels to be attached to units for sale, informing buyers of energy use characteristics and likely future energy costs, and mandatory energy efficiency standards for equipment.

The key challenge, however, is to foster the integration of building energy efficiency concerns into the building design process of design firms and building developers, so that they can develop the best means to improve energy efficiency under various conditions. To achieve this integration, two things are required:

- Designers and developers need to become more knowledgeable about the energy efficiency performance of different types of building designs, how to include energy efficiency analysis as part of the design process, and the various options and design approaches which can be incorporated to improve energy efficiency, yielding results without significant cost increases.

- Building or apartment/office purchasers need reliable information on the indoor climatic comfort levels and energy costs to expect from new buildings, to weigh as part of purchase decisions, and hence, bring energy efficiency market incentives to bear upon the building development industry.

In both cases, the role of the Government is chiefly to promote capacity building within the building development industry, organize and support demonstration of new ideas and innovative approaches, objectively evaluate performance in different new building projects, and publicize both the importance of energy efficiency and the actual results achieved in different cases. Public entities need to work in close cooperation with the building development industry.

Recommended Policy Actions. Increased and sustained Government support will be essential to achieve success in improving the energy efficiency of Chinese buildings in the coming years. To improve the heat supply system and make a major difference in the efficiency of energy use in buildings will require a broad effort, integrating actions by many different groups and agencies over a number of years. This can only be achieved in the Chinese system with top-level support, and effective organization which cuts across traditional organizational boundaries. Difficulties in achieving this more integrated approach has led to fragmentation of efforts in the past, and less success than originally hoped for.

Strong Government support is needed for two broad reforms in the heating zone: reform of the heat control and billing system, and effective implementation of energy efficiency building standards as part of the overall building code. Central government action is needed to provide direction for overall reforms, approve basic approaches, and organize implementation of the two required reforms. Important actions include interagency, high-level approval of a basic approach to heat billing reform, and further strong effort by MOC to insist on implementation of the building energy efficiency standards in the heating zone. Necessary investment approvals and financing to accompany reforms and enable implementation to proceed effectively need to be organized. Local government commitment and organization is the key to real implementation. It is essential at this time for several municipal administrations to take the lead in developing and implementing comprehensive programs, leading the way for others to follow.

At the municipal level, the first, basic elements of an initial program to get started in today's environment on achieving meaningful results in building energy efficiency might include: (a) development of a local implementation system to enforce the building energy efficiency standards for new buildings, including internal piping systems amenable to consumer control and direct billing; (b) analysis, followed by reaching a consensus on the broad direction for local heat billing reform, including implementation in new buildings first, followed, step-by-step, with reforms for existing buildings; (c) development of a program to evaluate more energy efficient building materials and other energy efficiency products, and to promote high-quality, effective products using market forces.

Outside of the heating zone, there are also needs for effective Government support, but more to work in alliance with market forces than to promulgate and implement major reforms. Key needs are for organization and support for actions by the different actors in the industry to develop more efficient new buildings, efforts to increase awareness, and support for development and dissemination of practical new model designs.

Specific Investment and Program Support. With proper incentives from regulation (standards) and policy adjustments, most investment should be undertaken by enterprises and consumers themselves. Commercial loans are the most appropriate source of credit, but credit from multilateral or local development banks may be appropriate in special cases where other sources of finance are not available. Public funds (e.g., from government, or international donors) should be used to promote the implementation of energy efficiency standards, policy reform, and establishment of an effective enabling environment for the market to work within.

Integrated Policy and Investment Pilot Projects. The greatest efficiency gains and cost savings to both consumers and the country can be achieved through an integrated effort, allowing improvements in the heat supply, billing and building envelope improvements to mutually reinforce each other. No city has as yet been able to implement such a comprehensive effort, but it seems clear that this is the next major step needed in China's building energy efficiency program for residential buildings in the heating zone, serving as a demonstration to others as to what can be achieved. An optimal multi-year program would integrate investment and reform in the heat supply system, a comprehensive program to reform the heat control and billing system, and a multi-faceted program to implement the building energy efficiency standards for all new residential buildings. Such programs could only be undertaken where there is strong commitment from the local city government at the highest levels, given the central importance of implementation of difficult heat billing reforms, and the need for integrated action by a wide variety of different agencies and groups.

Proposed high priority activities. To prepare for such a comprehensive program, the following activities, for which international support would be helpful, appear particularly urgent for the heating zone:

- Development and approval of model designs for horizontal, dual pipe internal building heat piping systems.
- Evaluation of heat metering and/or billing reform pilot project results in China.
- Evaluation of actual energy savings in past and/or ongoing energy efficient housing developments.
- Cost-effectiveness studies of various building energy efficiency measures
- Heat tariff studies.
- Evaluation of heat supply options by conducting proper economic analyses of the options for different areas, and develop planning accordingly.
- Workshops on (i) experiences and practical lessons learned in implementation of building energy efficiency standards as part of national or local building code enforcement and inspection, (ii) the design and implementation of government programs to assist low-income households to pay for heat bills, and (iii) implementation steps, problems and their solution, and other lessons learned by district heating companies who have at least partially made the transition from Soviet-designed supply-based systems to demand-based district heating systems.

Some high-priority activities for the non-heating zone include:

- Development and implementation of government-industry partnership programs for designing and building more energy efficient buildings.
- Research on results and cost-effectiveness of various energy efficiency measures.

Some activities which could make important contributions to the energy efficient building effort which are not specific to either the heating or non-heating zone include:

- Building design exchanges.
- Development of Energy Service Companies (ESCOs) focusing on energy efficiency services in buildings.
- Development of Government testing and certification of new energy efficient products and materials.
- Organization of large-scale procurement packages for new materials or products.
- Increasing information dissemination on new products.

CHAPTER 1. WHY PROMOTE MORE ENERGY-EFFICIENT BUILDINGS?

China has not yet achieved substantial results in efforts to improve the energy efficiency of space conditioning in urban residential and commercial buildings.[1] Some programs have been initiated, but gains have been less than originally hoped. Many other countries have succeeded in this area, but not easily or quickly: success must include a range of institutional actors working together and a number of social issues must be overcome, in addition to economic and technical ones. Each country must struggle to attain the best balance of improved incentives and government regulation to meet its own circumstances. Industrial energy consumption continues to dominate China's energy balance and much work remains to be done to improve industrial energy efficiency. Why should China bother with the complexities of improving building energy efficiency now?

Current Energy Waste in Buildings

China currently consumes about 130 million tons of standard coal equivalent (tce) per year just for space heating of urban residential and commercial buildings, according to MOC estimates. Most of this energy is wasted. Although comprehensive analyses have not been conducted, residential buildings in China are estimated to consume 50-100% more energy for space heating as compared to buildings in similar cold climates in western Europe or North America, and still provide far less comfort. Heat loss through exterior walls, which is the greatest single source of heat loss in these buildings, is about 3-5 times as high in Chinese buildings as in similar buildings in Canada and other northern countries (see Table 1.1). Loss through windows is over twice as high. Additional major losses are caused by imbalances and inability to control heat use in centralized heating systems, forcing consumers to commonly open windows as the only means to regulate overheating. Further losses follow a series of maintenance and management deficiencies stemming from the current heat billing system. China has long monitored the gaps between domestic and internationally advanced levels of energy use, and associated energy savings potential, in a wide range of energy intensive processes, such as steel production, electricity production, vehicle use, etc. Although the data is not precise, it is clear that backward technology and management practices make the gap between Chinese and developed country levels of energy use for comparable building space conditioning easily the largest of any major energy-use process.

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[1] This report focuses exclusively on space heating and cooling in urban residential and commercial buildings, and development of the tools required for the necessary improvements in building design and construction, including internal heating and cooling (HVAC) systems. Efforts to improve the energy efficiency of rural buildings also is very important in China, but the long-standing systems for building design, construction and ownership are quite different, and hence solutions require separate specific attention. Energy use for lighting, cooking or other appliances by building occupants also is an area where major efficiency improvements can be achieved, but, again, this involves a different set of tools.

Table 1.1: International Comparison of Building Envelope Thermal Standards
(Heat conduction coefficients of roof, exterior wall and window in W/m^2-^oK)

		Roof	Exterior Wall	Window
Beijing, China	Conventional design code	1.26	1.70	6.40
	1986 energy efficient code	0.91	1.28	6.40
	1995 energy efficient code	0.80 or 0.60/a	1.16 or 0.82/a	4.00
Russian region with comparable heating degree days		0.57	0.77	2.75
US region with comparable heating degree days		0.19	0.45/b or 0.32/c	2.04
Canadian region with comparable heating degree days		0.40/d 0.23/e	0.38	2.86

Note: Most Chinese buildings—including many new ones—tend to be in line with the conventional design code, or somewhere in between that code and the 1986 code. Very few new buildings are being constructed in conformity with the 1995 code even today, except in Beijing.

/a: The larger value refers to buildings with shape coefficient smaller than 0.3, while the smaller value refers to buildings with shape coefficient larger than 0.3. Shape coefficient is defined as the ratio between the outer surface area (four exterior walls plus roof) of a building and the volume of the building.
/b: External insulation.
/c: Internal insulation.
/d: Refers to non-flammable roofs.
/e: Flammable materials

Sources: MOC (1996); Tu Fengxiang (199), Presentation at China-US Building Energy Efficiency Workshop, Pittsburg, Pennsylvania.

Although even less firm data is available, electricity use for space cooling in urban residential and commercial buildings is estimated to have grown from very little at the outset of the 1990s to perhaps 40 TWh by 1999.[2] In contrast to many other countries, where the high costs of peak-load electric power have driven closer attention to measures to reduce cooling costs in building design and construction, China has yet to tackle this growing energy-efficiency problem.

[2] Tsinghua University, Institute of Building Environment and Service, 2000, *Report on the Investigation and Analysis of Building Energy Efficiency in China*.

New Building Construction: Locking in Energy Waste for the Future?

The most critical aspect of China's building energy waste problem is that the use of highly energy inefficient designs, materials and construction is continuing unabated through the current building construction boom. The following factors have converged to cause a huge boom in the construction of urban residential and commercial building floor area subject to heating or cooling since 1990, which is expected to continue for at least another decade:

- Steady urbanization, causing high population growth in large and medium-sized cities;
- High growth in household incomes, and corresponding increases in residential floor area per capita (increasing 40%, for example, from 10 to 14 square meters per capita between 1990 and 1998 (China Statistical Yearbook 1999);
- Especially rapid growth of services in the economy; and
- Increasing demand for heating outside of the traditional heating zone, and rapid demand for cooling across much of China.

Even if the construction boom is tempered somewhat, more than one-half of China's urban residential and commercial building stock in 2015 is expected to be constructed after the year 2000 (see Chapter 2). Demand for heating and cooling service in the new buildings will be greater than ever. The buildings which will be constructed over the next decade and a half will largely lock in future energy efficiency levels for decades—as each new building may be used for 50 or more years.

Most unfortunately, the majority of new buildings being constructed are still based on the older, highly energy-inefficient design principles. Central heating systems are usually still based on designs from the 1950s which allow no consumer adjustment of heat levels. The Chinese Government has promulgated new energy efficiency standards for buildings in the heating zone, aimed to achieve energy savings in new buildings of 50% compared to buildings constructed in the early 1980s, but the standards are generally not enforced. Solid progress has been made in developing more efficient building designs suitable for Chinese conditions, and various more energy-efficient windows, building materials, insulation board, etc., demonstrated in a number of pilot project efforts. But without enforcement of the building standards and changes in the prevailing heat billing system, neither the building design and construction industry, nor building owners and users, have the incentive to make the major changes necessary in heated buildings to move from pilot efforts to real implementation. In areas where central heating is less important, major opportunities to improve future energy efficiency and comfort in space cooling and decentralized heating through better design of new buildings also are being lost, although for somewhat different reasons (see Chapter 4).

Russia and other countries in eastern Europe and central Asia also face problems similar to those in China concerning the great energy inefficiency of existing buildings and heating systems. But the extent of new building construction in China makes China's case unique. It provides both a major opportunity to "grow out" of much of the problem, but also a danger, if not addressed, of locking in enormous energy waste and inefficiencies for future generations. It is not an exaggeration that China has the most to gain of any country in the world from successful implementation of an effective building energy efficiency program.

Social and Financial Imperatives

Space heating is a basic need for survival in most of northern China, where winter temperatures can drop to –15 to –30 degrees C. Urban space heating has been considered a government-sponsored welfare requirement in northeast, northern and northwestern China for decades. Beginning as an in-kind or monetary subsidy to households in the 1950s, the heating welfare system has evolved to include systems whereby the work units of urban households pay for the centralized heating system services provided to their employees. With the construction boom and substitution of centralized heat for heating with small coal stoves, the total floor area of buildings supplied with central heating quadrupled between 1990 and 1998 (China Statistical Yearbook, 1999). Accordingly the system whereby work units directly paid heat service companies operating building boilers or district heating systems has greatly expanded.

The sharp economic downturn in Northeast China during the late 1990s, coupled with the great inefficiencies of the heating supply and use systems, has created a financial crisis for these heating systems. Financially strapped work units have been unable to pay heating bills, and collection rates for heating fees have fallen from above 90% to averages around 60% since the mid 1990s. Municipal governments have been confronted with both huge heating system financial losses and increased needs among poorer or unemployed households for assistance in paying for basic heating needs. In Shenyang, the municipal government had to set up a heating guarantee fund and allocate RMB 100 million per year since 1996 just to keep the city's systems running. Municipal resources have now proved insufficient: in a drastic measure, the central government was forced to inject RMB 300 million in 1999 to alleviate the financial crisis facing the heating companies in Harbin, Changchun and Shenyang, the three largest cities in the Northeast.

Fundamental resolution of these problems will take time and requires simultaneous action on a series of difficult fronts, including (a) reform of the heat billing system to make end-users accountable for heat bills calculated based on actual heat consumption, in line with other ongoing housing and state-owned-enterprise reforms; (b) adoption of methods to increase end-user control of their heat usage; (c) measures to improve end-user heating comfort levels and reduce end-user costs by improving the efficiency of heat use by end-users; (d) investment and operational/management reforms in heat supply companies to reduce inefficiencies and costs. Improvement in the efficiency of space heating within buildings is a key, intertwined part of the necessary package:

- Increased consumer control of heat use and user incentives to improve heat use efficiencies, through billing system reform and through changes in internal piping and metering systems, or at least a combination of adoption of control at the building level with deployment of heat allocation metering, must be implemented to provide the foundation for true efficiency improvements in the central heating systems. A shift to a <u>demand-based</u> foundation for the district or housing block heating systems is a necessary platform for investments in heat supply system re-optimization, technological upgrading and operational reform to yield the best improvements in system efficiency. In Poland, the cost of apartment heating was cut in half through efficiency gains by both consumers and heating companies in a 1991-99 program combining a shift to consumer control and direct billing with investment in district heating system upgrading in four cities. This cost reduction made a parallel reduction in municipal government household heating subsidies from 67% to almost zero more palatable to consumers. (Of course, both happened at the same time, and the reduction in subsidies also provided incentives for the energy savings to occur in the first place.) See Box 3.1.

- Well designed, cost-effective improvements in the energy efficiency of buildings can both save a lot of money on heating bills and improve comfort levels. This greatly reduces the financial burden to society as a whole, paid by consumers or, where welfare support is still required, by the state. Differences in new buildings can be dramatic. Experiences in the US indicate that residential buildings constructed according to new, more energy-efficient designs can yield energy cost savings of 30% or more with virtually no increase in construction cost. In China, the commonly cited estimate is that new, more energy-efficient buildings can save 50% or more on energy costs with increases in construction costs of some 10%. Although low-cost savings are more difficult to achieve in retrofitting measures on existing buildings, cost-savings through improvements in internal heating systems, use of thermostatic valves, door and window renovations, roof insulation, etc. can still add up. In Lithuania, a World Bank-supported program to improve energy efficiency within existing buildings has yielded cost-effective energy efficiency gains of some 20-25%. Of course, consumers may harvest energy efficiency gains in the form of cost savings or in the form of comfort improvements, or any desired combination thereof, as long as they are able to control their heat supply.

Outside of the "heating zone", the same social imperative of heat supply does not exist, as households are able to survive without heating. In central and eastern China, summer temperatures of 38 degrees C or higher, and winter temperatures of 2-3 degrees C, are common. The great discomfort of living without space heating or cooling in this climate and the related health problems are well known by all. As incomes have risen, families with average incomes are paying for simple heating and for cooling systems. Attention to energy efficiency issues in the design and construction of new buildings can provide direct financial benefits to families, by reducing heating and cooling requirements for a given level of comfort at little or no extra construction cost. The higher winter indoor temperatures and lower summer indoor temperatures resulting from attention to energy efficiency issues in building design and construction also can significantly improve living conditions for those who may not be able to afford space conditioning. In addition to consumer benefits, there also may be substantial benefits for local power utilities, as electric power demand for air conditioning tends to pull heavy peak-load power requirements, which is the most costly electric power to provide.

Environmental Benefits

Improvements in efficiency can substantially reduce current high environmental costs associated with space conditioning, especially heating. Coal continues to completely dominate energy use for space heating in China. Some 180 million tons of raw coal (i.e., about 130 million tce) were burned in 1997 for heating in residential and commercial buildings in the urban districts in the heating zone alone. This is more coal, in energy terms, than total current coal consumption for all purposes in the unified Germany. The resulting global greenhouse gas (GHG) emissions total about 350 million tons of carbon dioxide per year, which is about the same as the total annual GHG emissions of either France or Poland. Urban space heating also remains a key source of the very high local particulate and sulfur dioxide concentrations typical of northern Chinese cities. For example, dispersed heating boilers account for 70% of ambient particulate and sulfur dioxide in

Beijing during the heating season.[3] The operation of coal-fired heating stations and home stoves help elevate winter ambient air pollution levels in northern Chinese cities to 2-5 times the maximum levels recommended by the World Health Organization, making air in these cities among the world's most polluted. Substitution of centralized heating for use of small coal stoves, and expansion of city gas use for cooking (but rarely for heating yet) have enabled some improvements in the street-level and indoor concentrations of harmful air pollution from home heating. Yet the "tell-tale" winter increases in ambient pollution remain, as well as the broader and regional effects of coal burning in larger boilers with higher stacks. In addition, progress is highly uneven, and many northern urban areas which have gained relatively little during the last decade of economic growth also tend to continue to suffer the most from exposure to dangerous pollution levels from space heating.

Energy use for air conditioning, which was almost negligible 15 years ago, continues to grow at a torrid pace. Because about three-quarters of China's electric power is generated from coal, this also carries increasing national-level environmental impact. Excluding the large commercial building use, residential air conditioning alone required some 20 TWh of electricity already in 1997—for which some 10 million tons of raw coal were burned by power plants (Tsinghua Background Report, 2000).

Why Take Action Now?

Attaining real results in improving the efficiency of space conditioning in buildings is a long-term proposition, but progress requires concrete actions to be taken now, in order to make a difference. Serious action during the next 1-2 years on a number of the difficult problems constraining progress is urgent because:

- Every year lost in developing more efficient buildings locks in some 700-800 million square meters of urban residential and commercial building floor area with inordinately inefficient energy use for future decades. China has already lost a great opportunity to improve energy efficiency in new buildings during the last decade. Taking actions now can avoid even bigger losses during the continued construction boom expected over the next decade.

- China's recent and continuing implementation of major housing reforms offer the opportunity to align end-user incentives in support of more efficient energy use in residential buildings. As families, as opposed to work units, buy and own their homes, their attention to heating and cooling comfort, and their interest in minimizing utility costs, can provide a powerful market-based lever for improving building energy efficiency if supporting policies and programs are put in place.

- Improving the end-use efficiency of heating in buildings is one of the key measures necessary to alleviate the current financial crisis facing the municipal heating systems in northern China. Reforms in the configuration and billing systems for home heating also serve both ends—they are of central importance for improving both the technical and financial position of the heating companies, and the efficiency of heating energy end-use.

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[3] World Bank, Second Beijing Environment Project, Project Appraisal Document, Report No. 20284-CHA, May 2000.

CHAPTER 2. SECTOR BACKGROUND

BUILDING STOCK AND CONSTRUCTION TRENDS

The total residential and commercial building useful floor area in China stood at about 33 billion square meters in 1998 (See Table 2.1). Simple, 1-3 story rural residential homes, built and owned by farming families, accounted for 71% of the total. However, the urban residential and commercial building stock has grown especially fast in the 1990s, increasing from 5.4 billion square meters in 1990 to 9.4 billion square meters in 1998.

Table 2.1 Residential and Commercial Building Stock in China
(billion square meters of construction floor area)

	1990	1995	1998
Rural residential	17.2	20.8	23.4
Urban residential	3.4	4.8	5.9
Commercial	2.0	2.9	3.5
Subtotal	22.6	28.5	32.8

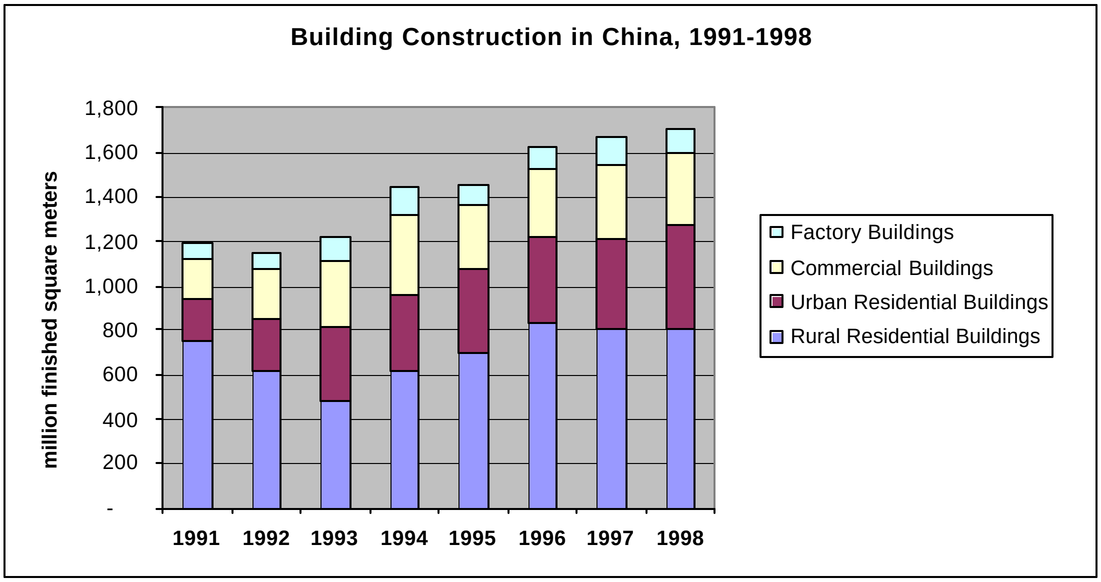
Source: Based on data of "per capita useful floor area" from China Statistical Yearbook, 1990-1999.

Construction During the 1990s

Due to significant demolition rates from urban renewal efforts, the construction rate for urban buildings has been even higher than the growth in urban building stocks (see Figure 2.1). Annual urban residential building construction in China rose every year during 1991-98, from 188 million finished square meters in 1991 to 476 million square meters in 1998, with an average rate of completion of 342 million square meters per year. This means that some 46% of the urban residential housing stock in 1998 was constructed during the last 8 years. The very strong growth in urban residential housing construction stems from the coincidence of several factors: (a) steady urbanization in the population in general; (b) increasing demand for more space as incomes rise (urban useful residential floor space increased from 9.9 square meters per person in 1990 to 13.6 square meters in 1998); and (c) major urban renewal programs.

A similar strong growth pattern exists for commercial buildings. During 1991-98, an average of 292 million square meters of commercial building floor area were completed each year. In 1998, fully two-thirds of the commercial building stock had been built during the last 8 years. This has followed the very strong growth of the trade and services industries.

Figure 2.1 Building Construction in China, 1991-1998



Source: China Statistical Yearbook 1991-1999, and World Bank staff estimates.

In the late 1980s, about three quarters of urban residential floor area was in low-rise buildings of three stories or less. This has changed. By 1997 low rise buildings had fallen to only about one-half of the urban residential stock. The most popular new residential buildings are 5-6 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 24% of the residential floor area.

Although there are many new designs for new, expensive, privately built homes, the ubiquitous multi-story, multi-unit residential buildings found throughout Chinese cities follow relatively standard designs and construction procedures. Basic construction materials are usually bricks, for the walls, and pre-fabricated cement slabs for floor and roof bases. New wall materials are beginning to be introduced, however to replace bricks, and, at times, to improve insulation. Steel window frames have been the norm, but plastic frames are becoming more popular of late in high-end buildings.

Commercial buildings house offices, hospitals, hotels, shops, restaurants, and other non-manufacturing facilities. In 1996 and 1997, about 40% of newly constructed commercial buildings were office buildings, while 35% were for commercial services, 20% were for cultural and educational purposes, and 5% were hospitals or research facilities. The new high-rise office towers, upscale hotels, and modern shopping centers in large Chinese cities, using modern heating, ventilation and air conditioning (HVAC) systems, are a completely new class of commercial buildings in China which has emerged only during the last 15 years.

Future Construction Trends

The basic factors that led to the urban construction boom of the 1990s—especially rising incomes and urbanization--are expected to prevail over at least the first decade of the new century. Further urbanization of the population is expected to be a particularly strong trend. It should result in robust new residential and commercial building construction in China's many mid-sized cities and towns, in addition to the major metropolises. Although detailed and sophisticated forecasts are not readily available, it is highly likely that half of the total urban building stock in 2015 will have been constructed after 2000.

BUILDING OWNERSHIP, PRICES AND MARKETS

Urban Housing Reform and Home Pricing

Under the socialist centrally planned economy, most urban homes were owned by various state-owned enterprises or agencies. In some cases, local governments constructed housing blocks for general public rental, but generally, housing was owned by places of employment ("work units"), that allocated apartments to their employees. Home allocations generally followed a system of seniority. Families were charged nominal fees for apartment rents. Together with utility services, retirement provisions, and many other services, housing costs were borne largely by work units, and housing was one of many types of "wages in kind". Monetary wages were low, and intended primarily to cover out-of-pocket expenses, such as food and clothing, not covered directly by the state.

With the shift to the socialist market economy, a critical requirement to enable enterprises to operate effectively under market conditions is to relieve enterprises of the wider range of social obligations to their employees, and to more fully monetize wages and benefits. While a number of the relevant reforms began during the 1980s, implementation of the critical elements of the state-owned enterprise/employees welfare reforms began in earnest during the 1990s. The key elements of housing reform, a central part of the overall reform, began during the mid 1990s.

The general aims of housing reform in China are to transfer home ownership away from employers primarily to individual families, to commercialize the housing sector and "commodify" housing, and to improve overall housing conditions. Homes which are already occupied are being sold by work units to employees at discount prices, with the level of discount usually based on the number of years of employment and age of the building. Base prices for saleable public housing were RMB 860/square meter in Changchun and RMB 1070/square meter in Tianjin at the end of 1999, but discounts typically reduce the prices paid by large amounts, averaging perhaps one half. By the end of 1999, typically some 50-60% of existing homes considered ultimately saleable had been sold to individual occupants in northern Chinese cities. Further progress is expected to be gradual but steady. Sale rates were expected to increase at the end of 2000 by an additional 10% in Changchun and Tianjin, reaching 50% and 70% of ultimately saleable housing by the end of 2000, respectively.

New homes are now generally sold by housing developers at market prices. Prices vary substantially, based on location and type of home. In Beijing, there are four types of new housing: luxury commodity homes, regular commodity homes, economic homes and low-rent homes. Economic homes and low-rent homes are supported by the government for use by low-income occupants—the government provides subsidies and often retains ownership. New commodity homes are sold to families at market prices, with buyers assuming *de facto* property ownership.

Policies were put in place at the beginning of 1999 mandating that work units should not allocate new homes to employees, but instead, employees without existing housing should purchase their own from their wages, which, accordingly, should be increased to include some type of housing compensation allowance. With typical prices of RMB 2000-3000/square meter (over RMB 4000/square meter within the Fourth Ring Road in Beijing), new 70-square-meter flats sell for over RMB 140,000—a great burden for the average family. Accordingly, the affordability of housing for new home purchasers, which is defined by the relationship between wages (including various housing compensation monies), housing prices and bank loan terms, has become a major social issue in Chinese cities today.

Urban Home Ownership and Markets

With perhaps a half of Chinese urban families owning their own homes at the turn of the century, and new employees required to purchase their homes, consumer demands are beginning to make big imprints on the housing industry for the first time. Under the old system, consumers were allocated housing by their work units, with little choice or input. Now, with home ownership expanding, consumers have real stakes in their homes. Home improvement and apartment renovation businesses are booming. Housing developers are now, for the first time, faced with very discriminating purchasers, who are weighing one of the most important financial decisions of their lives. The role of the market is uneven, however—the housing system for lower income families is more difficult to "commodify", and allocation of low-income housing has not changed a great deal. For middle and upper income groups, however, the economic framework is changing radically.

Another important change is the emergence of new housing management companies in China. Except for some large institutions, which may still maintain their own housing management staff, new residential developments are managed by commercial housing management companies, paid by residents, usually through a fixed charge based on floor area. These companies perform various duties, including general maintenance and grounds work, community security, and other publicly-shared services. While the developer often may determine which housing management companies will receive initial contracts, the business has become increasingly competitive. In cities where home-owner associations are more developed, residents decide who to hire. The housing management companies could play an important role in facilitating building energy management, especially in space heating, because of their direct and contractual relationships with residents.

Much of the current and near-term future focus of housing reform is to further deepen and continue the work of the past, to integrate new solutions for low-income housing, and to develop secondary housing markets. Secondary housing markets are just beginning to develop in major cities—in the case of Beijing, this market opened in 1999.

Housing Reform and Building Energy Efficiency

Some of the key implications of the ongoing housing reform for efforts to improve the energy efficiency of residential buildings include the following institutional/economic framework changes: (a) the greatly expanded role of the consumer, consumer choice, and consumers' interests (especially comfort, convenience and economy), (b) the emergence of market-driven housing development companies, (c) the emergence of new types of housing management companies, operating under market conditions in buildings where flats have been privatized; and (d) the break-up of work-unit supported housing, which can pave the way to the phasing-out of work-unit financed residential space heating.

BUILDING DESIGN AND CONSTRUCTION SYSTEMS IN CHINA

Traditional System under the Planned Economy

The old system for building design and construction included: (a) design institutes; (b) construction units; (c) building materials production units; and (d) government or work unit building purchasers. A relatively small number of design institutes, associated with government agencies or universities, designed buildings under a system of standardized designs, within a fairly rigid and homogeneous culture and practice. Construction units implemented the designs, using materials allocated largely according to the annual plans, and produced by state or collectively owned building materials production units. Buildings were constructed to meet orders from government agencies or work units, who then allocated flats to their employees. An advantage of the system was its ability to develop large numbers of buildings according to standardized designs. Disadvantages included great difficulties to foster changes or innovations, as this often required agreement and changes in the plans behind the whole system, and insufficient demand feedback from either building purchasers or occupants.

The Evolving System under the Market Economy

During the 1990s, new systems began to evolve under market conditions. The legacy of the previous planned economy remains in many ways, however, so that the current building design and construction system is a mixed system, which will continue to change in the coming years.

The biggest changes have been the introduction of competition based on market principles and the expanded role of consumer demand. Although the government sets "guidance" prices for design fees (as percentages of overall construction costs), competition between design institutes has been introduced, and many new design companies have entered the market. Competitive tendering for building construction is now a common practice. Changes in the economic operating framework of the building materials production industry, in particular, have been dramatic: producers of brick, windows, insulation, wall board, concrete block, paneling, accessories, etc. all now operate within a general market framework, often facing fierce competition. (Continued lack of flexibility in some building material and design standards, however, continue to hamper materials innovation.) Finally, a new, more market-based real estate development industry is being formed, with some companies built upon old-system institutional relationships and other new companies being developed, but both facing needs to meet the increasingly sophisticated demands of consumers. The developers have become a focal point in the system, and many encompass the full scope of the business: they obtain the land permits, mobilize the upfront financing, engage the design institutes, contract the construction companies, and market the units.

Despite the introduction of competition, however, older institutional relationships between various government agencies and the range of enterprises in the housing design and construction business remain critical in the industry.

Examples from Beijing Municipality. In the case of Beijing, about 500 building design institutes were operating in early 2000, of which about 100 were classified as "Class A" enterprises, the highest level. Classifications are closely regulated by the government. Only a handful of well-established building design institutes associated with large state institutions are employed for most large projects, especially those financed by the state. However, these firms now account for less than one-quarter of the total business volume, with a large number of smaller companies playing a critical role for the many medium and smaller-scale development projects. On the construction side, the construction industry, also including different classifications of enterprises, is generally required to respond to bids. The real estate developing companies have become the central actors.

HEATING AND COOLING IN URBAN BUILDINGS

China's Climate Zones

Climatic conditions in China vary dramatically across the country. Chinese analysts commonly divide the country into five regions (see Map 1). Space heating is definitely required in the "heating zone" (the two "cold" regions), which together account for almost one-half of China's total residential building floor area. The regions include:

- **Very Cold Region** (19% of residential floor area)**.** Winter heating is a critical aspect of daily life in this region, and centralized heating, including both district heating and apartment block heating from individual heat-only boilers[4], has long been developed in urban areas in this region. Some of the region's cities include Harbin (with average temperatures during the heating season of –9.1 to –10.0 degrees C), Changchun and Urumqi (-8.1 to –9.0 degrees C), Hohhot (-6.1 to –7.1 degrees C), and Shenyang (-5.1 to –6.0 degrees C). Cooling air conditioning is generally only provided in upscale hotels and shopping centers.
- **Cold Region** (27% of residential floor area). Centralized heating was developed fairly early in a few of the cities in this region (e.g. Beijing), but is relatively new in many of the somewhat warmer cities of the cold region (e.g, Tianjin. Jinan, Zhengzhou and Luoyang). The region includes Lanzhou and Taiyuan (with average temperatures during the heating season of -2.1 to –3.0 degrees C); Beijing, Tianjin and Dalian (-1.1 to –2.0 degrees C); Xian and Jinan (0.0 to 0.9 degrees C); and Luoyang and Zhengzhou (1.0 to 2.0 degrees C). As summer temperatures may exceed 35 degrees C on some days, air conditioning is becoming quite common among in all manner of commercial buildings and higher-income households.
- **Hot Summer, Cool Winter** Region (37% of residential floor area). In this region, no heating or cooling infrastructure has been provided until recently. Yet, there are 60-80 days per year where temperatures fall to less than 5 degrees C, and 15-30 days when temperatures exceed 35 degrees C. With little provision traditionally for heating or cooling, residents in this region often have suffered from the most uncomfortable indoor room temperatures of all—indoor temperatures of 4-6 degrees C in winter and 32-33 degrees C in summer are common. Some of the cities in this region include Shanghai, Nanjing, Changsha, Chongqing and Wuhan.
- **Hot Summer, Warm Winter** Region (14% of residential floor area). Summer air conditioning has grown sharply in this region. Heating is not needed. Cities include Guangzhou and Fuzhou.

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4 District heating systems include a heat network encompassing a large number of buildings, incorporating various substations and a variety of sources of heat supply. "Individual heat-only boiler" systems supply centralized heat for apartments in one or just a few buildings, without substations or a significant inter-building network, and based on heat from separate small boiler-houses.

- **Temperate** Region (3% of residential floor area). As outdoor temperatures are mild throughout the year, neither cooling nor heating are major requirements. Cities include Guiyang and Kunmin.

Map 1: Climate Zones in China

Source: MOC

Heating Systems

The main heating systems used in urban northern China include room heating with small coal stoves and centralized heating with hot water room radiator systems, fed by individual apartment-block heat-only boilers or district heating systems. Small coal stoves are the traditional method, but these are being gradually replaced, beginning from the 1950s. Centralized heating developed first in areas of the most densely populated urban districts in the Very Cold Region, but has expanded greatly during the late 1980s and 1990s, as incomes have risen and air pollution concerns have grown. Centralized heating now dominates large and medium-sized city heating in the Very Cold Region—in Harbin, for example, virtually 100% of the residential floor area in the city center used central heating in 1998. A bit further south, in the Cold Region, central heating has grown steadily. In Beijing Municipality, for example, central heating has grown to supply 63% of the urban floor area in 1995, up from 46% in 1985. However, coal stove heating remains common in older, single or double-storied buildings in the outlying parts of Beijing and many other northern cities and in small cities and towns. Coal stoves also are common for urban room heating in the Hot Summer, Cool Winter Region.

District heating systems, relying upon a combination of large heat-only boilers and cogeneration units, have grown throughout the heating zone in recent years, but they still supply less than half of the overall urban central heating. In Harbin, the district heating system supplies about 40% of the residential floor area, while individual boiler systems supply about 60%. About two-thirds of the heat supply for the Harbin district heating system comes from large heat-only boilers, while one-third comes from cogeneration units. In Beijing in 1995, district heating supplied about 25% of the urban floor area, while central heating based on individual boiler systems supplied 38%. About one-half of the heat supply for the Beijing district heating system comes from cogeneration units.

Coal is the largest fuel source for all systems, by an overwhelming margin. Natural gas and electricity based heating is just beginning in a few parts of northern China.

Chinese centralized heating systems are still mostly based on the same Russian designs found across the Former Soviet Union and Eastern Europe, except that only heat, and no domestic hot water, is provided from the central systems. The constant-flow systems are simple, but do not allow any regulation of heat supply by consumers. Piping systems within buildings are mostly vertical, single pipe systems—hot water is pumped to the top of the building and then via vertical-drop pipes through stand alone radiators, floor-by-floor, in different apartments. Radiators in a given flat are not connected with each other, but connected to the radiators of neighbors above and below. Apartment-level metering is not undertaken, as billing is calculated based on heated floor area and not heat consumption.

Indoor temperatures of centrally heated apartments in the heating zone are typically in the 13-18 degree C range. Because of system imbalances, however, and lack of adjustment capabilities, heat supply varies dramatically between apartments and apartment blocks. One case recently documented showed that in a 57,500 square meter system supplied by a 10 tph boiler, apartment room temperatures varied from 9 degrees C in the last building on the system to 28 degrees C in the first. Where rooms are overheated, the only option for occupants is to open the windows.

At the government level, each city (or county or district) government in the heating zone has a special division, usually called "gongreban", or "heat supply office", which supervises local winter heating activities. These offices endeavor to help coordinate activities among a series of different types of heat suppliers. Central heating systems are typically managed by one of four types of entities: (a) relatively large heat supply companies managing large systems, which are often corporatized former government units: (b) local housing management bureaus or other government housing authorities, which run the heating systems for public housing units; (c) work units which operate their own independent heating systems; and (d) housing developers, who may operate independent community heating systems. Operational efficiencies tend to be low. The larger systems typically have qualified technical staff, but they are beset with a host of other constraints stemming from their operating environment. In the small systems powered by individual boilers, a lack of professional management has been a chronic problem. Boiler house jobs are usually filled by seasonal workers with insufficient training, and systems are not properly maintained, but only repaired when mishaps occur. Poor operation and maintenance usually account for 15-20% efficiency loss in these systems, compared with 5-10% losses in well-maintained systems.

Heat Prices

Prices for centralized heating in a number of cities are presented in Table 2.2. Although some households may now pay a small portion of the bills, the heating bills are still generally paid by employers and not households themselves. The nominal average heat bills per 60 m^2 flat vary substantially, from about 1000 yuan in Beijing to about 1450 yuan in Harbin. According to official estimates, in the three northeast provinces (Heilongjang, Jilin and Liaoning), bills for heat supply at current prices are equivalent to 15-30% of individual household incomes. However, if local average wage rates are used as a reference, the heating bill for a 60 m^2 flat would be equivalent to about 5% of the salary of an average double-income family in Beijing, and about 13% in Harbin.

Table 2.2 Prices for Central Heating in Selected Cities, 1999
(1999 yuan per square meter construction floor area per season)

	Tianjin	Beijing	Dalian	Shenyang	Urumqi	Changchun	Harbin
Heating degree days	2285	2450	2568	3602	4293	4471	4928
Heating price	18.5	16-20	17	19	19.5	22.5-23.5	24.15
Connection charge	93	35	60	not avail.	70	58	40

Sources: Tsinghua Background Report, 2000; Degree days: MOC, 1995.

Residential Space Cooling Systems

Space cooling in residences has been introduced only during the last 10 years, but has grown rapidly. Air conditioners for home use are now mostly of the split-unit type, rather than the less efficient window units. As shown in Table 2.3 below, penetration has reached high levels in some provinces, but is directly correlated with climate and income.

Table 2.3 Household Ownership of Air Conditioners in Selected Provinces, 1998

Province/Region	Number of Air Conditioning Units Per 100 Urban Households
Heilongjiang	0.4
Liaoning	1.3
Beijing	34.0
Tianjin	45.0
Shanxi	3.1
Shandong	15.2
Hunan	20.7
Shanghai	68.2
Fujian	24.2
Guizhou	1.1
Guangdong	71.1
National Average	20.0

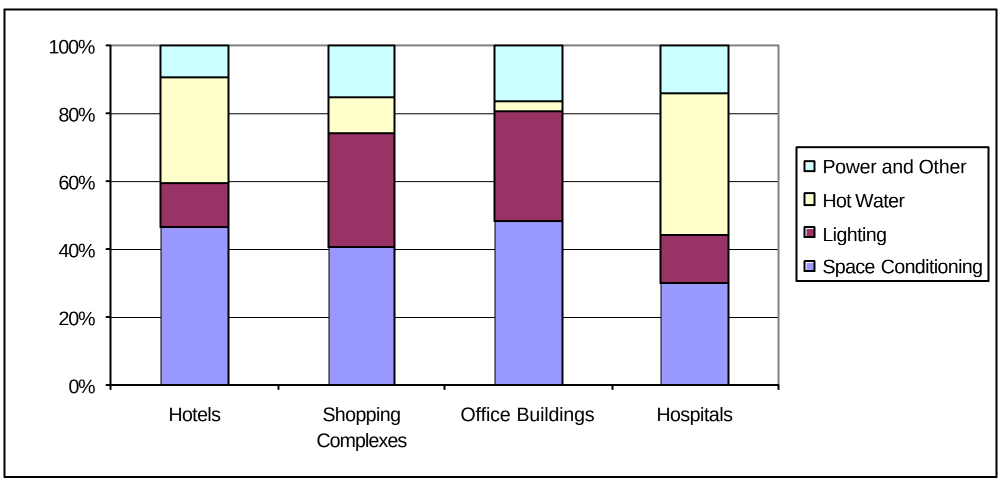
Source: Tsinghua Background Report, 2000.

Commercial Buildings

Few older commercial buildings have modern heating, ventilation and air conditioning (HVAC) systems. Space conditioning needs may be met in various ways with variable quality, or forgone altogether. Systems may include centralized heating or portable heaters for space heating and window or split-unit air conditioners for cooling. However, the situation has changed for new shopping complexes, office buildings, hospitals, etc. Some 60-70% of the new commercial buildings in large and medium-sized southern coastal cities are equipped with modern HVAC systems. The percentage is lower in similar-sized cities in the Changjiang river region at 40-50%, and still lower in the north at 20-30%. Commercial building HVAC systems in Guangdong Province now account for 40% of urban electricity consumption. In Shanghai, the current share is 31%. Such figures indicate that commercial HVAC systems are or are becoming a major factor in urban peak electricity supply.

Figure 2.2 reveals energy consumption patterns in different types of commercial buildings with HVAC systems in Shanghai. Most of the space conditioning energy is used for cooling.

Figure 2.2: Energy Consumption Patterns in Commercial Buildings with HVAC Systems, Shanghai



Source: Tsinghua Background Report, 2000.

OVERVIEW OF PAST EFFORTS TO IMPROVE ENERGY EFFICIENCY IN CHINESE BUILDINGS

China has undertaken serious efforts to try to improve energy efficiency in urban buildings during the last 15 years. During 1980-94, efforts included a wide range of generally small pilot projects, trying out new approaches and technologies in building design and construction, and the issuance in 1986 of a Section on Building Space Heating within the new Design Standards in Residential Buildings, laying out standards to achieve a 30% improvement in energy efficiency compared with 1981 standard designs. In the mid-1990s, attention to the issue of energy efficiency in buildings expanded further, with (a) the establishment of a Leading Group for Building Energy Efficiency within the Ministry of Construction (MOC), with a permanent small Office of Building Energy Efficiency set up in 1994; (b) the development of ambitious plans to improve building energy efficiency in the new Office's "Ninth Five Year Plan (1996-2000) and 1996-2010 Long-term Development Plan for Building Energy Efficiency in China;" (c) issuance of the "Design Standards for Energy Savings in Construction Thermal Engineering and Air Conditioning in Tourist Hotels (effective 1994, a first energy efficiency standard for commercial buildings); (d) issuance in 1995 of an updated "Energy Efficiency Design Standard for Residential Buildings (for Heated Building Construction)", laying out standards to achieve a 50% improvement in energy efficiency compared with 1981 standard designs; and (e) a wide range of expanded pilot and demonstration building and new housing complex projects.

The 1995 Energy Efficiency Building Standards (JGJ26 -95)

Issued in December 1995 and effective in July 1996, MOC's Energy Efficiency Design Standards for New Heated Residential Buildings requires that new residential buildings or expanded parts of existing buildings should reduce energy use to 50% of the use in comparable buildings using the general 1981 building designs. The standard covers two parts: building thermal engineering and building heating systems. The standard specifies (a) maximum requirements for heat conduction coefficients for different parts of the building envelope (e.g., exterior walls or windows, see Table 1.1), for different heating season temperatures and general design conditions, accounting for 30 percentage points of the energy savings, and (b) minimum technical and material requirements for heat supply and networks (e.g., rated heat efficiency of boilers and pipe insulation thickness), accounting for 20 percentage points of the energy savings.

As discussed in the next chapter, there have been difficulties implementing the 1995 standards. In February 2000, MOC issued a Ministerial Order, the **"Residential Building Energy Conservation Management Regulations,"** which became effective in October, 2000. This order makes requirements to implement the 1995 Energy Efficiency Design Standards for New Heated Residential Buildings and the 1993 Energy Efficiency Standards for Tourist Hotels more specific. It stipulates that new residential building central heating systems should adopt two-pipe technology, indoor temperature control, and apartment-level heat metering, and implement heat-consumption based billing. It also spells out specific requirements for designers, developers, construction units and agencies responsible for review, approval and inspection. This new Regulation can provide a basis for a stronger effort to organize the implementation of energy efficiency building standards.

Pilot and Demonstration Projects

A wide variety of building energy efficiency demonstration and pilot projects have been implemented in China over the years, providing important, practical experience in use of new technologies, materials and design concepts. Some technologies, including higher quality plastic-coated metal rimmed windows, for example, have become increasingly popular in the general market, following earlier trials. Experts working on how to improve building energy efficiency also have become more aware of the main programs and technologies utilized abroad, through increasing international exchange. Demonstration efforts have generally focused either on building thermal envelope improvements or introduction of heat metering, but, unfortunately, rarely both.

Beijing Municipality may be the leader in terms of construction of new buildings using building envelope improvements yielding energy efficiency gains, but most northern Chinese cities also have gained some experience. The main focus has been on use of more efficient building materials—different types of bricks or cinder block, external or internal insulation board, improved windows and doors, etc. A number of large, newer projects focus on integration of an assortment of technologies together with more energy-efficient building design and subdivision layout principles. Demonstration efforts have also expanded geographically to include a growing number of projects outside of the heating zone (esp. the Hot Summer, Cool Winter, or "transition" zone). Various retrofit options also have been tried on existing buildings.

During the 1990s, different approaches to heat metering have also been tried out in different cities, including both systems relying on heat allocation meters and systems using apartment-level heat meters. In both cases a building heat meter is usually also installed. Many such projects are patterned after different European approaches, and may test different types of European equipment, but projects using domestically manufactured equipment also have been undertaken.

The useful results of the demonstration and pilot projects could be greatly enhanced with more systematic efforts to measure and evaluate results. Scientific monitoring and evaluation has often been weak. Proper economic analysis of the actual incremental costs and benefits of different measures has been even less common, and there is an urgent need to fill this gap, to better inform future investment projects.

As discussed in the next three chapters, the challenge for China now is to put the various strands of lessons learned, knowledge gained, technical advancements and policy reforms together into comprehensive efforts which can yield much greater results.

CHAPTER 3. IMPROVING EFFICIENCY IN THE HEATING ZONE

THE NEED FOR A "TWO-HANDED" APPROACH

To realize better results in efforts to improve energy efficiency in urban buildings in the heating zone will require a more comprehensive approach, encompassing both reform of heat system control and billing, and strong efforts to systematically implement building energy efficiency standards. The study team has nicknamed this approach the "two-handed approach."

On the "left hand", policies and programs must be implemented which make heat a commodity—to enable consumers to be able to control how much they consume, and pay according to actual consumption. Only then will consumers have incentives to use heat wisely, and realize the benefits which can be obtained from more efficient use. There are four, interrelated necessary reforms: (a) adoption of technical measures to allow consumers to regulate their heat supply: (b) adoption of some means to determine actual heat consumption and allow billing accordingly; (c) reform in the bill payment system, so that individuals pay for their heat use, rather than their employers or the state paying; and (d) reform of heat tariffs, so that heat is billed according to actual use (gcal), as opposed to heated area (square meters). The most critical of the reforms is the reform in the heat bill payment system—if and where this is achieved, the other reforms can be implemented relatively easily.

On the "right hand", policies and programs must be implemented to ensure that the energy efficiency building standards are more effectively adopted in practice. Widespread adoption of more energy efficient designs, materials and construction methods requires some basic changes in customary practices by a large number of different actors, and hence, a major organizational effort. Where and when the political will for such changes is present at the city level, at least three key measures are required: (a) mechanisms to ensure implementation of the energy efficiency standards must become an integral and regular part of the general building code inspection and enforcement system; (b) model designs and specifications, and detailed regulations, must be developed and issued for those key aspects of building and heat system design and construction where changes are critical, and professionals working on building design and construction management must be trained in the new methods; and (c) information dissemination and other programs to help spur the rapid, market-based development of new, more energy efficient building material products and technical approaches need to be implemented.

Effective implementation along either of the two fronts is a difficult organizational and techno-economic challenge; not to mention achievement of progress on both at the same time. However, experience shows that a "one-handed" approach will not work. Beijing Municipality, for example, has probably made the greatest gains of any Chinese city in its efforts to implement the building energy efficiency standards (e.g the "right hand"). As city officials and experts are among the first to point out, however, lack of action on heat system reform has seriously compromised results, and it is thought that little actual energy savings have been achieved. Even just-completed new buildings still use vertical, single pipe heating systems. Consumers are not able to turn-down their heat use when oversupplied, and building management companies and consumers have little incentive to do anything about it.

In Canada, the USA and northwestern Europe, heat has long been a commodity, sold and purchased through the market. Yet market forces alone have not been sufficient to achieve economically attractive levels of building energy efficiency: all of these countries found it necessary to also develop and implement energy efficiency building codes and standards, setting different types of maximum heat conductivity levels for new building designs and construction.

REFORM OF HEAT SYSTEM CONTROL AND BILLING

Consumer Control

Consumer control of heat supply is necessary to allow heat supply to best match demand. For new systems, this requires a variable-flow, two-pipe design, and use of manual valves or thermostatic radiator valves (TRVs). A horizontal pipe configuration for each apartment works best, since this allows greater control at the apartment level and metering of individual consumption at one central point. Existing constant-flow, vertical, single-pipe systems can be retrofitted to allow consumer control by adding control valves, radiator by-pass pipes, and making adjustments at the building/substation level to accommodate the flow variations. Incremental costs for new apartments are basically negligible relative to apartment selling prices. Incremental costs for retrofitting existing systems just to allow consumer control (excluding any metering) may be about RMB 300 for an apartment with five radiators, including bypass piping and manual valves, and a bit more if TRVs are used. If consumer controlled building systems become a sizable part of district heating systems, accompanying changes must also be made at central levels to allow operation to better match the peaks and troughs of demand.

Surveys in Russia and eastern Europe have shown that changes to allow consumer control of heat supply are highly popular. Some 80-90% of the urban citizens surveyed in a number of Russian and Lithuanian cities as part of World Bank projects strongly favored renovations allowing them to adjust radiator heat levels, because this allows greater control of comfort. In some cases, where heat supply has been chronically too low, consumer control may result in increased heat use, but typically, ability to turn down over-supply, particularly in spring and fall, is at least as important. Over-supply can be observed frequently in the existing constant-flow systems. Sometimes this is to ensure that the relatively cooler parts of the system are adequately heated. At other times it may be because the heat system cannot adjust quickly to weather changes. In addition, consumer control allows radiators in places not frequently used or temporarily vacant to be turned down or off. Although results will vary, in most cases consumer control, just by itself, will probably result in overall net energy savings.

Measuring Consumption Levels

For heat to become a commodity, its use must be measured so that it can be billed according to consumption. The minimum requirement is for centralized heat use at the building or apartment complex level to be metered and billed. Thereafter, the issue becomes how the centralized heating bill should be divided up amongst the building residents. Basically, there are three options:

- The building-level heat bill may be divided up amongst residents according to apartment floor area or any other mutually agreed method, without any measurement of individual apartment consumption. The advantage is simplicity and ease of implementation, but this does not provide direct incentives to individual consumers to use heat efficiently. In Finland, this system has operated efficiently for many years. In the U.S., however, continued use of this system in older apartment buildings with central heating is a leading cause of energy waste in such buildings.

- The building-level heat bill may be divided up with the assistance of heat use measurements from simple heat allocation meters. A heat allocation meter is a liquid-filled glass tube afixed to a heat radiator. They cost about US$ 4 each in Europe, and would probably cost much less if manufactured in China. The liquid evaporates slowly based on the heat around the radiator. Loss of liquid is measured at the end of each heating season, and the tubes replaced. Data is entered into a bill allocation computer program, which may also include other factors, such as apartment area or location. Individual consumer bills for a heat season are then adjusted accordingly. The advantage is that it provides a low-cost means to include some measurement of actual consumption in individual bills, and hence greater equity and provision of consumer incentives to use heat wisely. This method also can be employed in existing buildings, retrofitted to allow consumer heat supply control, but still with vertical pipe configuration. Disadvantages are that the measurements are crude, a determined consumer can falsify results, and the final calculation of bills is somewhat complex and may not be easy for consumers to fully understand; and

- Apartments may be billed individually, based on apartment-level heat meters. This is the most accurate, and perhaps fairest, way, and most effective means to provide direct incentives for efficient heat use. A key disadvantage, however, is that apartment-level heat metering can only be practically adopted where horizontal piping configurations are in place—so that all heat entering and exiting the apartment can be monitored at one spot. Retrofitting apartment piping from vertical to horizontal systems is a major, expensive construction job (costing RMB 21/square meter in the case of Changchunor in Shenyang). Another disadvantage is that heat meters are relatively expensive. In the same case in Changchun city, apartment-level heat meters imported from Europe cost RMB 2000 ($240) each. In China, however, models are being developed which may cost some RMB 500-1000 each. Another disadvantage is the need for proper water quality, otherwise meters can become clogged and rendered useless in even one heating season. Still, the cost of heat meters and any associated water filtering may well be very worthwhile for new buildings in China, if horizontal piping schemes are deployed at conception. In existing buildings, however, use of heat meters would be prohibitively expensive in most cases, due to piping retrofit requirements. An exception is where retrofitting to horizontal piping and heat meters also serves to solve bill collection problems-such retrofits also enable heat companies to cut off supply to individual apartments, e.g. for lack of payment. (With vertical piping systems, individual apartments cannot be easily cut off, and only apartment groups can be cut off—often making it difficult to penalize only non-paying customers.) In Changchun, piping retrofits and deployment of heat meters have been undertaken in a number of apartment blocks to serve such dual purposes. Indeed, only such a partial demonstration of the possibility of piping retrofits and a tough payment enforcement policy may serve an important role in improving bill collection.

China has gained some pilot experiences with each of the above methods, and different solutions and combinations can be tried and expanded. Many Chinese officials and experts working in the field believe that the use of individual heat meters is the only sound solution for the long term, given customs, preferences, and experiences in previous metering reforms. In the Bank team's opinion, however, two points are important regardless of the preferred metering technology: *(a) metering and billing according to actual heat consumption at the building or apartment complex level is required in all cases, and should be implemented as soon as possible; and (b) new buildings should be constructed with horizontal/dual pipe systems, which entail virtually no extra cost, but allow apartment-level supply and cut-off flexibility, and apartment-level metering at any desired time in the future.*

Shifting to Household Payment of Heat Bills

Responsibility for payment of residential heat bills needs to shift from the state or employing work units to individuals, as in other market economies. This is necessary to eliminate the notion that heat is a social "free good", instead of a commodity. The reform is necessary in order to: (a) provide some incentives to use heat efficiently, in line with its costs to the country, (b) make the payment system fairer to consumers, allowing consumer payments to be more in line with what they actually use; and (c) provide the basis for commercializing the heat supply industry, thereby improving its efficiency and financial viability. Where low-income families require financial support for this basic need, this can and should be efficiently provided through the government, but the ultimate responsibility for payment should be shifted to the household, and the billing relationship should be developed in a commercial way directly between heating companies and consumers (or their agents). Box 3.1 illustrates this process with examples from Poland. It should be noted however that at the beginning of the process in Poland, the heat costs were much higher than today in China. A similar decrease in real tariffs should therefore not be expected. The current heat billing system is one of the last, heretofore unreformed parts of the welfare system of the centrally planned economy which now needs to be placed on a market footing, as already launched in housing, social security and other areas. The reform is required both to a make it possible for heat to be used more efficiently and to allow heating companies to commercialize and gradually become financially sustainable.

The need for heating billing system reform in China is well known and an area of considerable current attention, but social concerns make the reform difficult. Detailed implementation methods must be developed at the city level, but central government support also is critical. During the Spring of 2000, a working group from six relevant ministries and commissions was actively developing proposals for how to manage and implement the reform for senior leadership consideration. A number of major cities also were actively wrestling with implementation proposals and designing potential programs.

Tianjin Municipality is perhaps the most advanced in the development of the reform. Following intensive discussion during 1999, the city government has promulgated a new billing management method, which is being implemented over 3 years. The basic concept in Tianjin is for all households to become responsible for paying their heat bills. Work units would be expected to provide a "heat fee compensation" as part of regular wages. The program is being phased in gradually, with the percentage of the bill paid by households (as opposed to work units) increasing in steps to 100% at the end. Arrangements will need to be made to manage cases where households cannot cover their bills from wages (e.g., through establishment of some types of special support funding facilities), but it is hoped that this problem will not block the key, strategic shift in responsibility for heat payment, and the progress of the reform in the majority of households.

In Northeast China, city governments in Shenyang and elsewhere are also considering approaches similar to that in Tianjin, but the more critical nature of the heating requirement, and the current economic downturn up north make the reform more complex. Basically, the share of households who would be unable to fully pay heat bills today, e.g., due to lack of sufficient employment or because their work units are unable to make any increased payments, is expected to be far higher. Many work units currently are unable to pay the heat bills of their employees under the current system, which has contributed to the decline in heat bill collections noted previously. Focusing on these problems, some alternative approaches rely on the city government to play a role in collecting work unit contributions and financing a share of home heating bills, with households paying an increasing share. This may, however, lead away from the goal to put the heat supply industry on a commercial footing.

Box 3.1 Experiences in Heating Metering and Billing Reform in Poland

With partial support from a World Bank loan over 1991-1999, the four Polish cities of Warsaw, Kracow, Gdansk and Gdynia undertook renovations of their heat supply systems, disseminated building-level heat meters for existing buildings, and reformed the heat tariff from a square-meter based tariff to a two-part tariff charged at the building level.

Results in Four Cities

	1991/92	1999	Change
Household heat bill subsidy (%)	67	<5 (1994)	
Heat bill charged to households (1999 US$/$m^2$)	13.7	6.2	-55%
Heated floor area (million sq m)	63.8	68.6	+7%
Heat energy sold (gcal/sq m)	0.27	0.22	-18%
Energy savings			22%

The Government of Poland implemented energy sector reforms under which payment for heat gradually became the responsibility of households, and they began to use heat more efficiently. Households (or companies operating as their agents) invested in radiator valves (TRVs), heat allocation meters, better windows and some insulation. The internal piping systems of buildings generally was not changed—single-pipe vertical systems are still in place, but radiator bypass pipes have been added where not already in place. A key result was that the costs of heating a given apartment area fell by 55%, due to efficiency improvements by consumers, and to technical, operational and management improvements in the heat supply companies. This reduction in costs helped to make the removal of the subsidy less burdensome to households.

Nationwide, household heat subsidies, provided by municipal governments, have been reduced from 78% in 1991 to zero by the end of 1997. Installation of building-level heat meters has been mandatory for all buildings since 1999. Use of heat allocation meters has become a popular way to allocate heat bills within buildings—a total of 5.5 million were installed as of 1997 in about 30% of the dwellings nationwide. (Apartment-level heat meters are generally considered too expensive.) More than 10 companies have been formed and compete in the market for billing services—including allocation meter installation, meter reading, billing and maintenance. Energy savings, reflected in customer heat bills, stemming from the reform (including savings from private investments spurred by the reform) typically range from 20 to 40%. Water quality improvements, however, were required before the metering could be effective. It also should be noted that apartment heat levels were generally adequate in Poland before the reform—in other cases (e.g. Lithuania), energy efficiency gains may be harvested more in terms of improved comfort level instead of energy savings.

Source: World Bank, Implementation Completion Report for a Heat Supply Restructuring Project, Report No. 20394, June 2000.

Reform of Heat Tariffs

The current tariff, whereby heating is charged according to heated floor area, needs to be reformed to a tariff whereby the primary charges are made according to gigacalories of heat consumed. This is necessary to provide incentives for consumers to use heat efficiently. A two-part tariff is recommended, similar in many ways to the common electricity tariff for large industrial customers, including: (a) a capacity charge, based on heated square meters or contracted maximum demand (eg. Gcal/hour), designed to defray at least a large portion of the costs of fixed assets of heat supply companies, and (b) an energy charge, based on Gcal consumed per billing cycle. Total revenue from the two parts should be sufficient to allow the heat company to cover all costs, including depreciation and interest charges, and to operate on a fully commercial basis without subsidies, maintaining both short-term and long-term financial viability. Determination of the ratio between the two parts must consider both (a) the best balance between financial security for the heat company, which will prefer to minimize unpredictable variations in revenue, and the need to provide strong incentives for efficient use of energy; and (b) needs to provide proper signals to consumers concerning both the costs of capacity and energy. In most systems, 60-70 percent of the revenue is best collected through the energy charge, and 30-40 % through the capacity charge.

If the resulting heat tariff levels are too high for poor households to be affordable, those households should be supported through general social support measures.

Opport unities for Modernizing Heat Supply Companies

The above four-point reform program in heating control systems and billing (eg. establishing consumer control, measurement of consumption, shifting payment to households and tariff reform) entails a major impact on heat supply companies. The change to a demand-led operating environment means that heat supply companies will need to plan, manage and operate in ways more similar to those of electric power or gas companies—demand is subject to changes controlled by consumers, and the operator must be able to adapt the supply system accordingly. But the reform can also put the billing system on a true commercial footing, allowing heating companies to become real commercial enterprises.

Although substantial specific investments to modernize system equipment, and management and operating methods, must accompany the billing reform measures, successful billing and system control reform offers a foundation for undertaking a true and fundamental restructuring of heat supply companies to properly operate in the market economy. The case of Poland offers a good example; see Box 3.1. The poor condition of most of China's heat supply companies—in terms of financial conditions, system technology, and needs for modernization in both equipment and management methods—is well known, and similar to the previous situation in Poland. Built together with the system control/billing reform measures described above, comprehensive efforts to modernize and commercialize heat supply companies might best include the following type of package:

- Investment for modest system renewal and adaptation of heat supply system substations and controls to variable flow, including development of decentralized substations;
- Corporate management and system operation reform and training;
- Commercialization of billing systems, based on commercial principles and direct billing of users;

- Tariff reform, to enable cost recovery from bill collection revenue, and two-part tariff billing, incorporating billing of measured energy; and
- Separation of heating enterprises from the government.

Sequencing Implementation of Heat System Control and Billing Reforms

All four of the reform measures described are needed to achieve good results, and they are all interrelated. In terms of first steps, however, perhaps the following combination is both attainable over the short-term and can provide the footing for the broader effort. Immediate action on the following is recommended:

- Central government, senior-level determination of the basic principles for undertaking the transfer of responsibility for payment of heat bills to households, and implementation of this reform in several pilot municipalities.

- Development, dissemination and implementation of standards for double-pipe, horizontal piping configurations to use in new centrally heated buildings; and

- Large-scale expansion of demonstration applications of building-level heat metering, and implementation of regulations allowing billing in these cases to use two-part tariffs, including energy charges. In existing buildings, renovations should be undertaken to allow consumers to control heat use. A variety of mechanisms can then be used to allocate heat bills to households.

IMPLEMENTATION OF BUILDING ENERGY EFFICIENCY MEASURES

Reform of the heat system billing and control is one key measure that will lead to improved buildings energy efficiency; the other is to improve the energy efficiency of buildings themselves. Aside from changes in heating and cooling systems, the main means to improve energy efficiency in buildings (achieve the same comfort levels with less energy) are to reduce thermal transfers through the building envelope (roof, walls, windows, doors and floors), to take best advantage of natural conditions (solar energy, wind direction, etc.) in building design, and, especially in large commercial buildings, to optimize air flow and balance heat transfers within buildings. This requires a degree of attention specifically to energy efficiency concerns in building design, and availability and use of specialized materials.

Improving Energy Efficiency in Existing Buildings

Major improvements in the energy efficiency of existing buildings (excluding heat supply systems) are generally not very cost-effective (i.e., payback of investment of more than 10 years), as basic designs are already set, and major retrofits are expensive. However, if consumers have incentives to reduce heat bills, and means to control heat supply, simple measures, such as caulking of air leaks and weather-stripping, can yield noticeable results. In addition, as Chinese families assume ownership of their homes, installation of more energy-efficient doors and especially windows may be attractive to families who are pursuing home improvements anyway, if the knowledge exists and good, cost-effective products are locally available. Although installation of new exterior wall insulation board on existing buildings usually is not cost-effective if the only benefit is energy savings, some building owners have been willing to incur such costs for aesthetic reasons.

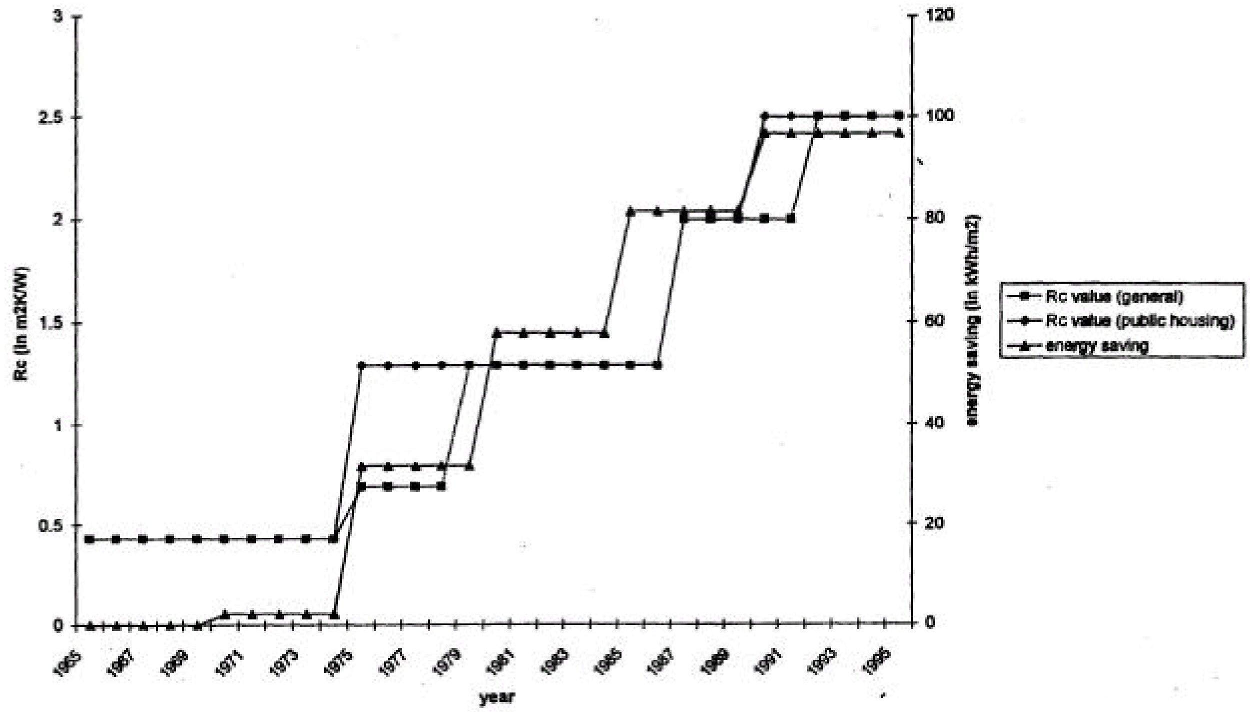
In some western and eastern European countries, some companies have been able to profitably add businesses providing specialized energy-efficiency services to residential and commercial customers to existing related businesses. Housing management companies, heat distribution companies, firms engaged in home improvement contracting, or companies in charge of heat bill allocation and collection can undertake activities to advise customers on measures which will make money, and assist in materials purchase and installation. Heat distribution companies or any other firms involved in heat bill collection (and hence able to monitor heat use by consumers), also may be in a good position to provide a money back guarantee to customers if their heat bills are not reduced as much as expected, as a way of enlarging their business opportunity (see also chapter 4).

Implementing Building Energy Efficiency Standards to Improve Energy Efficiency in New Buildings

Why Promote Building Energy Efficiency Standards? Interest in maintaining comfortable indoor temperatures at minimum cost becomes one factor which office, shop or apartment purchasers consider when they buy new building space, if they are accountable for paying the bills. These incentives are critical for effective implementation of programs to improve building energy efficiency. However, broad international experience over the last 25 years has shown that by themselves these incentives are not enough to cause the full potential for cost-effective energy efficiency improvements in new buildings to be realized. Families purchasing an apartment or businesses buying new office space must consider many factors (e.g., location, convenience, room configuration, durability, appearance, resale value, etc.). The cost of future heat bills may often be a factor, but rarely the most central one in making final choices. The power of individual consumer interest alone is not enough to cause the major changes needed in the building development industry, which encompasses a range of diverse actors. Although many energy efficiency improvements can be attained by relatively modest design modifications and with little or no extra cost, the inertia of standard designs and practices in the industry is difficult to change, even if changes ultimately benefit all concerned. The financial and comfort interests of individual consumers, as well as the additional major societal benefits of improved energy efficiency, need to be aggregated and more forcefully represented for many cost-effective measures to be implemented. This is why virtually every country with major heating requirements in buildings has adopted some form of mandatory building energy efficiency standards. The key is to make these standards (a) simple and understandable, and appropriate to the skill and technology level of the industry, (b) clear and enforceable, (c) flexible—allowing different paths to achieve compliance, (d) cost-effective—all required investments should be financially viable over the life of the investment, and (e) amenable to implementation through the existing building permit process.

Where energy efficiency building standards have been simple, developed with the involvement of the industry, and properly enforced, good results have been achieved, especially in North America and northern Europe. As an example, Figure 3.1 tracks the implementation of building efficiency standards and energy efficiency improvements in the case of the Netherlands.

Figure 3.1: Insulation Standards and Energy Savings in the Netherlands, 1965-1995



Note: Rc is the reverse of the heat conduction coefficient (see Table 1.1) and is measured in m^2K/W.

Source: Schaefer, C. et al (2000): Effective Policy Instruments for Energy Efficiency in Residential Space Heating - an International Empirical Analysis (EPISODE). European Commission, Non Nuclear Energy Programme JOULE III. http://elib.uni-stuttgart.de/opus/volltexte/2000/726.

The staged introduction of energy efficiency standards for new dwellings since the 1970s had a strong influence on energy savings. Significant reductions in the consumption of space heating can be observed for houses built in 1975 or later when compared to older houses. The above figure illustrates this by showing the increasing strictness of Dutch standards and the increase in energy savings (i.e., decrease in heating energy use) by vintage, as estimated by a linear regression analysis controlling for other factors.

Improving Implementation of China's 1995 Building Energy Efficiency Standards. *To improve results in implementation of China's 1995 Building Energy Efficiency Standards, local governments must include the most important measures in the standard building design and construction code for new buildings, and these several energy efficiency standards must be enforced through the existing building permit and code inspection system.* Few city governments have yet undertaken serious initiatives to implement the energy efficiency standards. The key will be for more and more city governments to implement changes in the building permit and inspection system to include the energy efficiency codes as regular parts of the systems already in place.

Beijing Municipality has made the most progress in implementing the building energy efficiency standards. The work has involved three municipal commissions—the capital city planning commission, the construction commission, and the city infrastructure management commission.[5] Detailed management of the program is undertaken by the Office of Wall Materials Renovation (OWMR), whose original mission was to promote the replacement of clay bricks with other materials. All new building designs now must have a specific energy efficiency stamp, certifying compliance with the energy efficiency standards, in order to receive construction commission approval of the blueprints. During construction, regular building inspectors are expected to check that required energy efficiency measures (eg. wall insulation) are undertaken according to blueprint specifications. At building completion, buildings for which the procedures have been followed properly will be certified as energy efficient buildings. If problems are found by the OWMR, it has the ability to block the issuance of sales permits.

Beijing's efforts clearly are an important step for China's work to implement the energy efficiency standards. The current system of multiple checks seems to have worked fairly well, and violations are reportedly few.[6] It should be noted, however, that the program has benefited from the relatively high profit margins of new residential buildings there, and better supply of insulation materials and energy-efficient windows than is likely for some other northern cities. To further improve Beijing's program, and help instruct other areas, it would be most worthwhile to undertake a full evaluation of results achieved, experiences gained, and lessons learned. It also is clear, as mentioned previously, that minimal changes in the heat supply system of new buildings must be undertaken and integrated into the program, to allow consumers to control heat supply, and to enable achievement of better energy savings results.

For most city governments in the heating zone, the critical step now needed for implementation of the standards is to develop the necessary consensus and senior-level support of the various actors who must be involved for a meaningful effort. MOC's new Residential Building Energy Conservation Management Regulations (see Chapter 2) should provide an important impetus. Once a decision to move forward has been made, the Bank study team has the following suggestions for instituting implementation programs, based on experiences elsewhere:

- It is important for the energy efficiency standards be implemented through the existing building design and construction regulatory system, as relatively modest adjustments to the existing code and the inspection/permitting system which enforces it. This is the avenue taken by other countries which has achieved success. A special energy efficiency inspection and enforcement system outside of the regular system should not be necessary;
- A specialized unit at the city level needs to be assigned responsibility for managing the process of integrating implementation of the energy efficiency standards into the current system (including tasks described below). The unit need not be large, but must have authority to institute changes and sufficient technical expertise;
- Implementation needs to proceed in close cooperation and consultation with the various other institutions and actors involved, in an effort to be as practical and realistic as possible. Public information campaigns also can be very helpful, as a means of garnering public support;
- It is best to focus, at least initially, on just a few measures which can be easily checked in designs and at construction, and will make the biggest difference in energy savings. This

[5] This institutional setup is unique to Beijing.

[6] In one reported violation case, the builder was found to have not met wall insulation requirements in the building plans only after one knowledgeable homeowner accidentally damaged the interior wall. The builder was forced to renovate walls through the whole building to correct the substandard insulation.

might include, for example, specifications on just wall insulation, windows and internal heat pipe configuration. It is more important to get several key changes actually implemented than to develop the perfect, comprehensive system. Simple and specific prescriptive codes may be simplest to enforce. However, flexibility should be maintained to allow designers and developers to use means other than those specifically prescribed, if they can demonstrate that equal or better energy efficiency results will be attained;

Box 3.2 Moscow's Building "Energy Passport" Program

Beginning in 1994, the City of Moscow has implemented an "Energy Passport" program as a specific feature of the city's new Moscow Energy Saving Regulations. The Energy Passport is a document which is part of the overall design, construction and sale documentation for any new building. At each critical step in the building design, construction and completion cycle, the compliance of a building project with the energy efficiency standards of the city's government is documented in the Passport. The Passport is a primary means for controlling the quality of building design and construction from the energy efficiency perspective, and formally documents the extent of compliance with relevant regulations. For example in 1998, 25% of the designs were sent back to the originators because they did not comply with the standards. When a building is completed, the Energy Passport becomes a public document, which provides specific information on the energy efficiency of the building to potential buyers and residents. Hence, the Energy Passport serves both regulatory and market functions: it serves as a means to track and enforce implementation of building energy efficiency standards, and as a government-certified "energy efficiency label" for consideration by buyers.

Source: Y. Matrosov and I.Butovski, NIISF/CENEf, and D.Goldstein, NRDC, USA: New Regulations of Energy Saving in Buildings in the City of Moscow. CENEF EE Bulletin 1999. (http://www.cenef.ru/bulletin.htm).

- Procedures for checking the implementation of the few energy efficiency codes agreed on must be detailed and rigorously applied in the existing system, or implementation will be a certain failure. The "Energy Passport" system used by the City of Moscow might provide a good system for some Chinese cities (see Box 3.2);
- The key parties in the system must be adequately trained in the new energy efficiency codes. Both principles and models which meet the codes must be understood by designers. Construction units may need to be trained in new techniques. Building inspectors must be trained in how to check that the energy efficiency codes have been met. Integration in the existing system is made easier through the development and certification of a number of design adjustments and more energy efficient products. Training requirements still are immense, however, if programs are to succeed; and
- Blatant violations must be penalized forcefully. Often, several well-publicized cases at the beginning of program implementation can make a major impact.

Developing Energy Efficient Building Materials and Products

Construction of more energy efficient buildings requires a wide range of various new or improved types of products, such as various types of external and internal wall insulation wall materials, improved bricks or other building block, building internal pipes (for example, plastic pipes made from PVC), energy-efficient windows, improved doors, heating and cooling system equipment and accessories, meters, etc. Over the past decade, a variety of new such products have been developed on some scale in China. Yet, the quality, sophistication, diversity and especially availability of such items remains relatively poor. This is largely because use of such materials in building designs and by building developers is still a low priority, as design institutes and developers are not, as yet, under serious pressure to develop more energy-efficient buildings. Where pressure has been applied, a basic contradiction is often heard: building designers and developers claim they cannot build more efficient buildings because the materials are not available, while the material producers say they cannot supply larger quantities of such materials, or develop new products, until there is evidence of stronger demand. This problem has existed in other countries as well.

The consensus in other countries with market economies is that it is most important to break this logjam by putting primary focus on developing demand, through implementation of efficiency standards which will require use of improved materials, and then let the materials and product supply industry react and cater to that demand over time. It is essential for the market to be the prime driver of the necessary innovation and material and product industry development. If there are problems, then the efficiency standards can be phased in over time, or gradually made more rigorous. In addition, however, there are a number of ways in which the government can help to move development of the market:

- Government testing and certification of new products and materials can increase developer confidence, and assist suppliers. Box 3.3 introduced one example from Sweden. In China, a very worthwhile package could include: (a) government institute testing of the energy efficiency and perhaps some other quality aspects of certain new products and materials (for example, wall board), based on standard tests; (b) government certification of products which meet specific minimum energy efficiency performance levels (e.g., as required by the building energy efficiency standards); (c) integration with local energy efficiency standards enforcement, such that use of certified products and materials eases design approvals for both applicants and approvers. Although this requires significant government investment and organization, it alleviates major designer/developer concerns about which products actually meet advertised performance and which products will meet the government code, and it greatly assists the market development for producers who pass the certification test;

Organization of large-scale procurement packages for new materials or products can provide the demand for the producers to expand development of new, innovative materials or products. Box 3.3 provides an example of this as well. If the demands from a number of developers can be aggregated, with coordination support from the government, the combined procurement package can be large enough to entice producers to develop relevant production capacity. Aggregated procurement packages may focus on the development of a new product currently absent in the market, expansion of production of certain products in short supply, or a combination of these. Procurement packages could be directly associated with published targets concerning implementation of new energy efficiency standards—making it clear to producers that demand following a specific procurement package will further develop. In the Chinese case, it may be relatively easy to organize among state-owned purchasers first, as the core purchasers in aggregate procurement packaging; and

- Facilitation of expanded and timely information flow between developers and materials/product producers is important. Many mechanisms can be employed, such as newsletters, television and radio programs, work conferences, expositions, etc. Competitions and provision of awards also can help good manufacturers gain exposure and market share.

Box 3.3 Promoting More Energy-Efficient Building Materials in Sweden

Sweden has a long, successful history of promoting the development of energy-efficient buildings. Two programs to spur the development of more efficient building materials which may be of interest for Chinese application include:

Certification of building materials. In addition to other functions, the Swedish building code agency, SPV, also certifies building materials for effectiveness and durability and it shares the responsibility of building inspection with local governments. SPV has devised a "type-approval" system for certifying, once and for all, that a certain product complies with the overall building code, including energy efficiency provisions. Type approvals – e.g., for doors, window systems, insulation, heating systems - are issued after testing and factory inspections by the National Testing Institute. Manufacturers must pay a fee for the certification. However, the type-approval label tends to speed up design approvals at the municipality level, and substantially enhances the marketing of a product.

Fostering technical innovation through bulk procurement. The NUTEK (Swedish National Board for Industrial and Technical Development) program for energy efficiency in Sweden aims to accelerate the commercial development of more energy efficient products by playing a role in organizing large-scale product procurement. The impact of this type of procurement on technical change can be decisive since it brings technologies to market which have not been developed because of the concerns of individual companies about risk, cost and lack of articulated demand. The NUTEK program identifies a target product, process or system, and then gathers potential purchasers together with energy experts in a working group. The group drafts the targeted energy-efficient performance parameters, together with other requirements for the product to be developed. The lifetime annual running costs of the targeted equipment model must be substantially lower than those of existing alternative products already on the market. Manufacturers are then asked to compete for the opportunity to develop a prototype. From their side, the potential purchasers undertake to buy an agreed minimum quantity of the winning product. The aggregate order must be large enough to warrant a serious development initiative by the winning developer/manufacturer. NUTEK subsidizes the purchasers with a certain proportion of the purchasing cost of the new products, in order to cover the risks always associated with application of some new technology, under the condition that the product installations can be used for demonstration purposes. NUTEK also provides various forms of assistance with marketing the new product. Although NUTEK's first procurement, for high-performance windows, was initially a failure, the process provided important lessons. The second phase procurement was successful.

Source: IEA (1998) Energy Efficiency Initiative, Vol 2: Country Profiles & Case Studies. http://www.iea.org/pubs/studies/files/danish/dan2/07-dan2.htm

CHAPTER 4. BUILDING ENERGY EFFICIENCY OUTSIDE OF THE HEATING ZONE

About one-half of China's residential floor area is located outside of the "heating zone" of northern China. About 400 million people live in the "Hot Summer, Cool Winter Region" of central and eastern China, where winter temperatures generally range between 0-10 degrees C, but daytime highs in the summer range from 30-40 degrees C. Further south still, winters are warmer, and summers are hot. Throughout these areas, the Government has not been obligated to provide space conditioning. Any space heating or cooling basically has been left up to consumers to arrange and pay for, if they are able. Until the 1990s, the combination of cold and humid indoor conditions in winter, due to lack of heating, and hot indoor temperatures in summer, meant that indoor living conditions in central and eastern China were far less comfortable than up north. In many families cold-related health problems are common.

During the last decade or so, as incomes have risen, residents have increasingly taken measures to adjust their indoor conditions by themselves. Sales and installation of electric resistance heaters, electric heat radiators, air conditioners, electric hot water heaters and heat pumps have boomed. Modern commercial buildings are all adopting space conditioning systems. However, the massive increase in space heating and cooling outside of the heating zone has occurred in a haphazard way. Installation of heating and cooling systems in buildings developed during a previous era, with no consideration for thermal performance, often may yield exceptionally high waste of energy and money, and/or less comfort than hoped. Also, the building design and construction industry in many cases has not yet truly caught up with the trend, producing new buildings which will still be difficult to keep comfortable at reasonable cost.

With strong demands for space heating and cooling certain to continue, the necessary adaptation to meet these requirements as efficiently as possible is a key challenge for the building design and construction industry outside of the heating zone. Proper integration of space conditioning equipment and low-cost design and construction alterations to improve thermal performance and indoor climate in modern buildings in the region without significantly increasing costs are largely new topics, which are made that much more difficult by the variations in needs and climates across the region.

Role of the Market

A critical difference from space heating in northern China is that consumers further south must pay the costs of any space heating or cooling themselves. As heat outside of the heating zone, and any space cooling, are not considered basic necessities for survival, there is no state involvement in providing heat for social reasons, and arrangements for either heating or air conditioning must be made by consumers themselves, and fully paid for by them as well. In addition, the fuels used – mostly electricity - are well monetized, and payments linked to actual use. Energy prices generally conform with supply costs. Electricity used for space heating or air conditioning is directly billed to consumers, based on metered consumption, and payment requirements are relatively strict.

Given the differences from further north in energy billing, fuel type and the larger role of end-users, market forces can play a larger role in the promotion of energy efficiency in the non-heating zone. Under the current system, energy savings can more easily be translated into direct financial savings by end-users, and end-users are likely to be attracted to any greater comfort derived at low cost from energy efficiency improvements. Thus, efforts to foster greater energy efficiency can build upon natural market forces in ways which are not as possible under the current system in northern China.

It is important, however, to stress that efforts to promote greater energy efficiency in buildings in the non-heating zone should *build on* market forces; market forces *cannot* be relied upon exclusively to foster the wider range of cost-effective energy efficiency improvements which are possible and clearly in the long-term public interest. As years of experience in other countries have shown, government or other public efforts are still required to achieve good results in promoting energy efficiency in this sector—the point is that the best results may be achieved in efforts developed to incorporate, complement and work in concert with active market forces. Generally speaking, financial savings from improved energy efficiency is not a strong enough incentive for major change—other factors far outweigh energy efficiency in shaping consumer opinions about which residence or commercial space to procure. In the USA, for example, where energy costs represent about 9% of the costs of commercial building rent, on average, a 25% energy savings would results in only a 2% reduction in rent cost[7]. For both residential and commercial buildings, factors such as location, appearance, convenience of lay out, and especially first cost, are the most important factors weighed by purchasers. In China, if energy efficiency aspects clearly provided improved comfort, this may probably be a more important marketing tool, and when combined with small financial savings, may provide substantia l market force. Even so, it still must be remembered that changes in design, incorporation of new equipment or materials, and any increase at all in building sale prices stemming from energy efficiency measures represent major risks to developers, with uncertain benefits to them in terms of their ability to increase building sales and profits. Thus, although market forces are clearly important, it should not be assumed that market forces alone are sufficient to promote improvements in energy efficiency which are in the public interest.

Paying Attention to Energy Efficiency in New Building Design

Efforts are currently underway to design and implement building energy efficiency standards for the Hot Summer, Cool Winter Region. Especially important aspects of this work include the effort to institute energy efficiency requirements for new cooling, heating and HVAC equipment, and the establishment of benchmarks concerning the thermal performance of building envelopes. Development of standards concerning heat transfer can help to guide the design community and construction industry, and increase attention to the need to develop improvements. However, the problem does not lend itself to easily prescribed technical solutions. Simple addition of insulation is less likely to achieve cost-effective results, compared with further north. Improved performance during different seasons may call for different prescriptions, which need to be balanced. Climatic conditions also vary dramatically across the non-heating zone, and effective solutions in one area may not be appropriate for another. Any building envelope solutions which require a significant increase in first costs also are highly unlikely to be adopted—the risks to developers are simply too high, and the potential benefits to them too low.

The key challenge is to foster the integration of building energy efficiency concerns into the building design process of design firms and building developers, so that they can develop the best means to improve energy efficiency under various conditions. “Building energy efficiency concerns” should be defined as “how to improve indoor climatic comfort at lowest cost.” Outside of the heating zone, solutions to this problem in new buildings are likely to lie primarily in building

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7 Figures are for 1989. See Office of Technology Assessment of the US Congress, Building Energy Efficiency (1992).

design (aside from use of more energy efficient heating and cooling equipment, described below). For building designers and developers to better integrate energy efficiency concerns in new buildings, two things are required:

- Designers and developers need to become more knowledgeable about the energy efficiency performance of different types of building designs, how to include energy efficiency analysis as part of the design process, and the various options and design approaches which can be incorporated to improve energy efficiency. Needs to incorporate space conditioning equipment and comfort demands into building design are relatively new issues. There is a great deal of work which needs to be done to (a) evaluate the performance of various newly constructed buildings, (b) apply and utilize simple software to predict the comfort and energy efficiency characteristics of proposed different designs; (c) develop, demonstrate, evaluate and publicize a range of design alterations under different conditions. It is particularly important to improve knowledge about design changes which yield results and do not significantly increase costs.

- Building or apartment/office purchasers need reliable information on the indoor climatic comfort levels and energy costs to expect from new buildings, to weigh as part of purchase decisions, and hence, bring energy efficiency market incentives to bear upon the building development industry. Improved information can be developed in a number of ways, but ultimately, the most powerful messages are from demonstrated actual results and customer feedback.

In both cases, the role of the Government is chiefly to promote capacity building within the building development industry, organize and support demonstration of new ideas and innovative approaches, objectively evaluate performance in different new building projects, and publicize both the importance of energy efficiency and the actual results achieved in different cases. Public entities need to work in close cooperation with the building development industry. A number of ideas of where public programs might be effective, largely based on international experience, include:

- Organization of practical training for building architects and developers on methods to analyze the energy efficiency of different designs and alternative approaches. In China's case, cross-regional exchange and exchange with designers from other countries may be especially important.

- Development of a government/building industry partnership program for design, construction, and evaluation of demonstration energy efficient buildings which do not involve significant increases in upfront investment costs. A working example of such a program is the USA's "Build America" program (see Box 4.1). It be emphasized that any demonstration efforts must include a strong effort to monitor and validate measurable results in terms of comfort and cost—firm data is required to provide information impacts which are worth the effort of such projects.

- Development of programs to increase energy efficiency in government-owned buildings. Governments in many other countries have implemented such programs, as a way of setting an example and demonstrating the benefits of energy efficiency measures. In some countries, implementation of building energy efficiency standards or energy savings requirements focus on government-owned buildings first. Demonstration of more energy efficient designs and technologies in new government buildings is one way for the government to "buy down" some of the risk of adopting new approaches in the commercial industry, and has been proven in a number of countries to be an effective way of developing energy efficiency expertise and knowledge in the building development industry.

- Development of the building/apartment/office third-party appraisal or inspection industry, including comfort and energy cost analysis. Building appraisers work on contract for purchasers, providing an independent review of a given property prior to completion of the purchase. For families purchasing homes, which may represent the most important investment of their lives, the advice of outside experts is especially valuable. Topics such as expected temperature comfort in winter and summer, and expected heating and cooling bills, are natural topics in such independent appraisals, and could make a significant difference in strengthening market forces for energy efficiency improvements.

- Implementation of a government program to evaluate and certify energy efficient buildings. An example of such a program is the "Energy Star" program of the US, whereby buildings which pass a fairly rigorous energy efficiency standard inspection are provided with a public award ("star"), which informs the public and the market.

Box 4.1. The USA's "Building America" Program:
A Public-Private Partnership to Develop Energy Efficient Residential Buildings

"Building America" is a residential building energy efficiency program assisted by the United States Department of Energy (DOE). The goal of the program is to unite segments of the building development chain that traditionally work separately to develop more energy-efficient homes without increasing first cost, and yielding benefits for each participant in the process. The administrative costs of the program have been about US$ 5 million per year, and these costs are shared between the DOE and participating firms from the building industry. It is hoped that the program can penetrate 40-50% of the total new residential building market with innovative, more energy efficient design and construction methods over a ten year period.

The Building America program is primarily an organizational and publicity effort. Teams of architects, engineers, home building firms, equipment manufacturers, material suppliers, community planners, mortgage lenders, etc., are brought together under the program to try new approaches. A systems engineering approach is used, and the teams are trained in new techniques, implementation methods, and evaluation and testing. The program results in newly constructed high energy-efficiency buildings, serving a demonstration purpose. The target is to develop new homes that use 30-50% less energy than ordinary new homes (e.g compliant with the USA's Energy Star program), without higher first cost. Publicity of successful demonstration efforts is an important part of the program, adding to the benefits of the private firms involved.

Source: http://www.eren.doe.gov/buildings/building_america/

Improving the Energy Efficiency of Heating and Cooling Equipment

Improving the energy efficiency of heating and cooling devices is clearly an effective way to save energy and to reduce peak power demand. This includes adoption of higher efficiency models of common window or split-unit air conditioners, as well as expanded adoption of heat pumps, which are just becoming popular on the Chinese market. A minimum level of public intervention is to implement government-sponsored programs to subject different models on the market to standard energy efficiency tests, followed by restriction of the most energy-inefficient models and/or requiring standardized, government-endorsed labels to be attached to units for sale, informing buyers of energy use characteristics and likely future energy costs. In many developed countries, however, improved information alone has been considered insufficient. Life-cycle energy cost is only one of many issues balanced by consumers purchasing new equipment. In cases where equipment is purchased and installed by building developers, and sold as one small part of the building package, the energy costs of operating the heating and cooling equipment is likely to be even less of a consideration by the building purchasers. Although there may be some consumer interest, it often is not strong enough to truly push manufacturers to make sufficient advances in energy efficiency in new designs. For these and other reasons, many developed countries have implemented mandatory energy efficiency standards for equipment such as air conditioners, and history has generally shown that such standards have yielded major improvements in energy efficiency at attractively low cost.

Improving HVAC Systems in Commercial Buildings

Integration of modern, high efficiency HVAC systems with more effective building designs to ensure both high comfort in all parts of a commercial building and low cost is a mixture between a complex science and a type of art requiring much practical experience. Because the energy consumption of these buildings is large, and systems and buildings being constructed today will exist for many years, capacity building in energy efficient, yet comfortable commercial building design, especially through international cooperation, deserves special attention.

In addition, major improvements can be made in commercial building HVAC systems, through relatively minor retrofits, and improved control and management. Often, evaluation of the best means to lower energy costs and improve comfort in complex commercial building systems may be best undertaken by specialized firms. In many developed countries, energy service companies (ESCOs) have provided the expertise, management skills and, sometimes, the financing for system upgrades and/or improved system operation. These companies are typically compensated from a portion of the reduction in the commercial building energy bill—an attractive arrangement for building owners. A number of small firms have begun to explore this potential business in China, and this development should be encouraged. In some countries, programs to improve the energy efficiency in existing government-owned buildings (especially hospitals, government office buildings, large schools, airports, etc.) proved to be a major catalyst for the development of the building ESCO industry, which then expanded to help improve energy efficiency in other buildings as well, for the benefit of all concerned.

Cooperation with Electric Power Companies

The boom in electric heating and air conditioning equipment in eastern, central and southern China has become a major factor in the increasing sharpening of the peak load of the power system in these areas. Because the provision of sharply spiked peak power requires addition of capacity to serve only a few hours each day, supply of such power is usually far more expensive than the revenue received for its supply. It is therefore in the economic interest of the power companies to flatten this peak to the extent possible, and, because of this economic interest, power companies can and should be important allies in public efforts to improve the energy efficiency of heating and cooling in buildings in the non-heating zone. Cooperation could include power utility offers of discounts or rebates for use of certain types of high-efficiency equipment that reduce peak load, information campaigns among customers, power company assistance in identification of peak power saving measures, utilization of the customer data base and contacts for organization of energy efficiency promotion efforts, and other programs.

CHAPTER 5: RECOMMENDED FOLLOW-UP ACTIONS

POLICY ACTIONS

Increased and sustained Government support will be essential to achieve success in improving the energy efficiency of Chinese buildings in the coming years. To improve the heat supply system and make a major difference in the efficiency of energy use in buildings will require a broad effort, integrating action by many different groups and agencies over a number of years. This can only be achieved in the Chinese system with top-level support, and effective organization which cuts across traditional organizational boundaries. Difficulties in achieving this more integrated approach has led to fragmentation of efforts in the past, and less success than originally hoped for.

Strong Government support is needed for two broad reforms in the heating zone: reform of the heat control and billing system, and effective implementation of energy efficiency building standards as part of the overall building code. The reasons why these reforms are essential, ideas on implementation, and lessons learned in similar efforts in other countries are described in Chapters 1 and 3. Central government action is needed to provide direction for overall reforms, and approval of basic approaches. Important actions include interagency, high-level approval of a basic approach to heat billing reform, and further strong effort by MOC to insist on implementation of the building energy efficiency standards in the heating zone. Local government commitment and organization is the key to real implementation. It is essential at this time for several municipal administrations to take the lead in developing and implementing comprehensive programs, leading the way for others to follow.

The key requirement of Government today is to take decisive action to organize implementation of the two required reforms. Which units in the central government should take the lead for which aspects? Who will prepare and sponsor the required policy documents? Assignments for policy implementation then need to be clearly made. Necessary investment approvals and financing to accompany reforms and enable implementation to proceed effectively need to be organized. Which local governments will move first, and which pilot efforts should proceed immediately, to try out the more innovative and new aspects of the needed reforms?

At the municipal level, the first, basic elements of an initial program to get started in today's environment on achieving meaningful results in building energy efficiency might include: (a) development of a local implementation system to enforce the building energy efficiency standards for new buildings, including internal piping systems amenable to consumer control and direct billing; (b) analysis, followed by reaching a consensus on the broad direction for local heat billing reform, including implementation in new buildings first, followed, step-by-step, with reforms for existing buildings; (c) development of a program to evaluate more energy efficient building materials and other energy efficiency products, and to promote high-quality, effective products using market forces.

Outside of the heating zone, there are also needs for effective Government support, but more to work in alliance with market forces than to promulgate and implement major reforms. Key needs are for organization and support for actions by the different actors in the industry to develop more efficient new buildings, efforts to increase awareness, and support for development and dissemination of practical new model designs.

Specific Investment and Program Support

Through the policy and regulatory actions discussed above and in the previous chapters, this report recommends the development of a framework for fostering more energy efficient buildings, under which investments in more efficient buildings and, to a lesser extent, retrofits, can take place through the market. With proper incentives from regulation (standards) and policy adjustments, most investment should be undertaken by enterprises and consumers themselves. Public funds (e.g., from government, or international donors) should be used to promote the implementation of energy efficiency standards, policy reform, and establishment of an effective enabling environment for the market to work within. Commercial loans are the most appropriate source of credit, but credit from multilateral or local development banks may be appropriate in special cases where other sources of finance are not available. The sections below outline a number of specific investment or research/training/institution building activities which the study team feels could provide substantial contributions to the national effort to improve building energy efficiency over the next few years. In some cases, actions are already underway for implementation.

Integrated Policy and Investment Pilot Projects

While various localities have made successful efforts implementing different parts of the building energy efficiency agenda, no city has as yet been able to implement a comprehensive effort, integrating each of the most important aspects. The greatest efficiency gains and cost savings to both consumers and the country can be achieved through an integrated effort, allowing improvements in the heat supply, billing and building envelope improvements to mutually reinforce each other. It seems clear that this is the next major step needed in China's building energy efficiency program for residential buildings in the heating zone. An optimal multi-year program would integrate investment and reform in the heat supply system (with measures similar to those discussed in Chapter 3), a comprehensive program to reform the heat control and billing system, and a multi-faceted program to implement the building energy efficiency standards for all new residential buildings. More narrowly focused, but still very productive efforts might include a combination of just the last two points-- the "dual hands" of the approach recommended in Chapter 3— without specific integration of an investment and reform program for the heat supply industry. Such programs could only be undertaken where there is strong commitment from the local city government at the highest levels, given the central importance of implementation of difficult heat billing reforms, and the need for integrated action by a wide variety of different agencies and groups.

Of the two reforms of the "dual hand" approach, the most important, and perhaps most difficult, is the reform of the heat control and billing system—unless there is success in achieving the basic "commodification" of heat, it will be difficult to achieve serious overall success in improving energy efficiency in buildings in the heating zone.

Although difficult, implementation of integrated, comprehensive programs at local levels can serve as a demonstration to others as to what can be achieved by modernizing the heat supply system and implementing the "two-handed" approach for improving building energy efficiency. This seems to be the most important area for work in the next few years, given the current stage of China's energy efficiency program for buildings. However, there are also a number of more narrowly focused actions or projects which could make major contributions to the national effort, as suggested below.

Activities for the Heat Zone

In addition to the recommended integrated pilot projects, some activities identified by the study team which are particularly urgent include:

- *Development and approval of model designs for horizontal, dual pipe internal building heat piping systems.* Configuration of building internal piping systems in new buildings to allow consumer control and billing at the apartment level is essential for the future, and required by MOC's new Residential Building Energy Conservation Management Regulations. However, many local design institutes are not familiar with these types of designs, and models are not readily available. There is an urgent need, therefore, to develop model designs appropriate for Chinese conditions, and approve and disseminated them as standard design options. International expert advice also would be helpful. Training and dissemination activities also will be needed to accelerate adoption, once model designs are approved.

- *Evaluation of heat metering and/or billing reform pilot project results in China.* There is an urgent need to review the results and lessons learned to date from the various completed or ongoing Chinese pilot projects using different approaches and technologies for consumer heat control, internal piping reconfiguration, use of heat allocation meters or heat meters, and experiments in billing reform. A wide number of such pilots have been or are being conducted by various different groups. A systematic evaluation of results, and the advantages and disadvantages of different approaches, can provide practical information of critical importance for the development of much wider programs. This should also include proposals for different options to achieve billing reform.

- *Evaluation of actual energy savings in past and/or ongoing energy efficient housing developments. The existing lack of proper scientific information on the actual energy* efficiency improvements achieved in practice in various building energy efficiency projects in China, relative to other, comparable housing developments, makes it difficult to properly establish the cost-effectiveness of different measures, and the overall real impact of such programs. As it takes time to obtain results, there is an urgent need to implement a scientifically based measurement and evaluation program for new housing complexes, including measurement of energy use, indoor and outdoor temperatures in different housing complexes within the same cities.

- *Cost-effectiveness studies.* There is general lack of knowledge of the cost-effectiveness of various building energy efficiency measures in China, which is necessary if efforts are to set priorities to achieve the most gains for the least investment. An urgent first step is to collect, compare and analyze the actual costs in the Chinese market of different key components of more energy efficient buildings (eg. windows, wall insulation materials and installation, heat system control devices). Costs could then be compared simply with rated performance characteristics. Ultimately, however, it would be best to integrate the results of the cost information and analysis with proper studies evaluating energy efficiency results (as described above).

- *Heat tariff studies.* Prior to implementation of heat tariffs which include major energy use (Gcal) components, there is a need to conduct proper study of the best tariff structure for a given system, including the best breakdown between capacity charges and energy charges.

The study must balance both the structure of system fixed and variable costs, as well as the optimal consumer incentives. Such studies should be undertaken on specific municipal systems, and should only be undertaken where implementation of such a new tariff is planned for the immediate future.

- *Evaluation of heat supply options.* Options for heat supply may include large-scale district heating, small-scale/block-type district heating, use of isolated coal fired boilers, introduction of gas-fired boilers or individual gas-fueled apartment heating systems, improved individual coal stove systems, and electric heating, including through use of heat pumps. Especially with the gradual increase in market forces and competitive availability of a number of these options in given localities, many municipalities are in need of assistance to conduct proper economic analyses of the options for different areas, and develop planning accordingly.

International support would be helpful for any of the above activities. In addition, three areas where international workshops, involving exchange among experienced practitioners in China with those in other countries, may be especially worthwhile include:

- Workshop on experiences and practical lessons learned in implementation of building energy efficiency standards as part of national or local building code enforcement and inspection. Participants should be officials who have many years of experience in the details of this work, for both northern developed countries and developing countries.

- Workshop on the design and implementation of government programs to assist low-income households to pay for heat bills, with particular focus on measures taken by countries of the former Soviet Union and eastern Europe.

- Workshop on implementation steps, problems and their solution, and other lessons learned by district heating companies (especially in countries of the former Soviet Union and eastern Europe) who have at least partially made the transition from Soviet-designed supply-based systems to demand-based district heating systems.

Activ ities for the Non-heated Zone

Some high-priority activities identified by the study team include:

- *Development and implementation of government-industry partnership programs for designing and building more energy efficient buildings.* As described further in Chapter 4, a number of ideas where public programs might be effective at local levels, working in concert with the building developer industry include: (a) organization of practical training for building architects and developers on methods to analyze the energy efficiency of different designs and alternative approaches; (b) development of a government/building industry partnership program similar to the USA's "Build America", to develop demonstration energy efficient buildings which do not involve significant increases in investment costs: (c) programs to increase energy efficiency in government-owned buildings, to set examples for the market; (d) development of the building/apartment/office third-party appraisal or inspection industry to provide independent information to customers buying real estate, including comfort and energy cost analysis; and (e) implementation of programs to evaluate and certify energy efficient buildings, such as "Energy Star". One way to begin such work would be through discussions with local officials and industry representatives on which of these types of options for public-industry partnerships might be most practical and effective in the current Chinese environment, followed by an implementation plan.

- *Research on results and cost-effectiveness of various energy efficiency measures.* Recent or ongoing innovations in building design, and adoption of various energy efficiency measures in new buildings, need to be systematically evaluated and assessed. As in the heating zone, efforts need to be made to undertake scientifically sound, measured, evaluation of recent or ongoing projects, to inform future work on actual potential benefits of various measures. In addition, costs need to be systematically appraised, in order to derive a much better picture of the cost-effectiveness of various measures for both residential and commercial buildings in the non-heated zone.

Activities for All Zones

Some activities which could make important contributions to the energy efficient building effort which are not specific to either the heat or non-heat zone include:

- *Building design exchanges.* Great need remains for further training and exchange of Chinese building designers with architects in other countries on how to better incorporate energy efficiency into new building designs at low cost. Results are best if exchanges focus on concrete projects, and the Chinese architects involved in a position to immediately apply all that they learn in their domestic work.

- *Development of ESCOs focusing on energy efficiency services in buildings.* There is a great potential for business by Energy Service Companies (ESCOs), providing efficiency gains in HVAC system operation in commercial buildings or energy efficiency services for residents or building owners in residential buildings. ESCOs undertake investments and provide technical, operational and/or management services to improve energy efficiency, and receive their compensation by sharing in a part of the reduction in energy bills (see Chapter 4). The emerging industry of commercial and residential building management companies in China provides an excellent opportunity for development of ESCOs. Technical assistance and international private investment could accelerate such developments.

- *Development of Government testing and certification of new energy efficient products and materials.* Such a program can both increase building developer confidence in new products, and assist suppliers of good products to expand their business. A worthwhile package could include: (a) government institute testing of the energy efficiency and perhaps some other quality aspects of certain new products and materials, based on standard tests; (b) government certification of products which meet specific minimum energy efficiency performance levels (for example, as required by the building energy efficiency standards); and (c) integration with local energy efficiency standards enforcement, such that use of certified products and materials eases design approvals for both applicants and approvers.

- *Organization of large-scale procurement packages for new materials or products.* This can provide the demand for producers to develop new products currently absent in the market, expand production of certain products in short supply, or a combination of these. The Government needs to play a role to organize the procurement packaging in consultation with building developers. The procurement packages could be directly associated with published local targets on development of new energy efficient buildings, making it clear to producers that demand following a specific procurement package will further develop.

- *Increasing information dissemination on new products.* Public facilitation of expanded and timely information flow between building developers and materials/product manufacturers is important. A variety of mechanisms can be employed (newsletters, TV and radio programs, work conferences, expositions, etc.) Public competitions and provision of awards also can help good manufacturers gain exposure and market share.