Report No. 10813-CHA

China
Energy Conservation Study

February 4, 1993

Industry and Energy Operations Division
China and Mongolia Department
East Asia and Pacific Regional Office

FOR OFFICIAL USE ONLY

Public Disclosure Authorized

Document of the World Bank

CURRENCY EQUIVALENTS

Currency Unit = Yuan (Y) = 100 fen

	1980	1990	1992
Exchange rate:	\$1 = Y 1.5	\$1 = Y 4.7	\$1 = Y 5.5

FISCAL YEAR

January 1 - December 31

WEIGHTS AND MEASURES

gCE	=	10^{-6} TCE
Kcal	=	4.19 kilojoules = 3.97 Btu
kgCE	=	10^{-3} TCE
MTCE	=	10^{6} TCE
MW	=	10^{3} kW
TCE	=	7 x 10^{6} kilocalories
TOE	=	1.43 TCE
(TWh)	=	10^{9} kWh
ton of coal	=	0.7143 TCE, average (actual heating values vary)
ton of crude oil	=	1.43 TCE
m^3 of natural gas	=	1.33 KgCE
kWh of electricity	=	0.1229 KgCE (heating value)
	=	0.392 KgCE, in 1990 (thermal replacement value varies by year)

ABBREVIATIONS AND ACRONYMS

Btu	-	British thermal unit
CEM	-	Country Economic Memorandum
CFL	-	Compact Fluorescent Lamp
EEC	-	European Economic Community
ERI	-	Energy Research Institute
ESMAP	-	Energy Sector Management Assistance Programme
FYP	-	Five-Year Plan
GDP	-	Gross Domestic Product
GEF	-	Global Environment Facility
GVIO	-	Gross Value of Industrial Output
IEA	-	International Energy Agency
IEC	-	International Electrotechnical Commission
Kcal	-	Kilocalorie
kgCE	-	Kilogram of Coal Equivalent
kV	-	kilovolt
kVA	-	kilovolt-ampere
kW	-	Kilowatt
kWh	-	Kilowatt-hour
MMEI	-	Ministry of Machinery and Electronics Industry
MOE	-	Ministry of Energy
MTCE	-	Million Tons of Coal Equivalent
MW	-	Megawatt
OECD	-	Organization of Economic Cooperation and Development
PEC	-	Provincial Economic Commission
FPC	-	Provincial Planning Commission
SEC	-	State Economic Commission
SEIC	-	State Energy Investment Corporation
SETO	-	State Economic and Trade Office
SPC	-	State Planning Commission
SSB	-	State Statistical Bureau
t	-	metric ton
TCE	-	Ton of Coal Equivalent
TOE	-	Ton of Oil Equivalent
TVE	-	Township and Village Enterprise
TWh	-	Terawatt-hour
WDR	-	World Development Report

FOREWORD

This study was completed by Robert Taylor (Senior Energy Economist), with inputs from Jayant Sathaye (Consultant) on electricity efficiency issues and with research assistance from Zhang Zhihong and Zhao Yangjun. The main mission (Messrs. Taylor and Sathaye) visited Beijing, Wuhan and Shanghai during October 1991, together with Xiong Sizheng (resident mission), and Yang Meicai (State Planning Commission, SPC). The mission is most grateful for the assistance provided by the study counterparts--the Department of Resource Savings and Comprehensive Utilization of SPC, and the Department of Energy Conservation of the Ministry of Energy. The mission also remains indebted to the provincial/municipal governments of Beijing, Hubei/Wuhan, and Shanghai for their most effective support.

CONTENTS

Executive Summary v

1 The Energy Intensity of China's Economy 1

A. Energy Consumption Patterns in China 1
The Role of Different Fuels 2
Sectoral Consumption Patterns in International Perspective 3
Energy Growth Trends in the 1980s 4
B. China's Energy Intensity in International Perspective 6
Factors Underlying China's High Energy Intensity 8
Some Statistical Issues in Energy Intensity Comparisons 10

2 Past and Prospective Macroeconomic Energy Intensity Changes in China 12

A. Overview of Energy Intensity Changes in the 1980s 13
Total Energy Intensity Changes 13
Summary of Factors Influencing Energy Intensity Changes 13
B. The Impact of Changes in Sectoral Demand Structure in the 1980s 16
The Role of the Residential Sector 16
The Role of Energy Industry Losses 17
Structural Change Between Production Sectors 18
Reductions in Sectoral Energy Intensities 19
C. Industrial Output Structure and Industrial Energy Intensity 19
Impacts of Change in the Structure of Output Between Industrial Subsectors 21
Changes in the Energy Intensity within Industrial Subsectors 22
The Effect of Trade in Energy-Intensive Industrial Products 23
Nontrade Structural Change Effects Within Industrial Subsectors 24
D. Policy Conclusions and the Outlook for the Future 28
Targets for the 1990s 28
The Role of Policy in Structural Energy Savings 29

3 Strategic Technical Energy Conservation Issues 31

A. Technical Energy Efficiency in Chinese Industry 31
Declines in Unit Energy Consumption in the 1980s 31
Sources of Success in Reducing Unit Energy Consumption 33
Unit Energy Consumption Levels in International Perspective 34
B. Strategic Issues for the 1990s 37
The Potential for Improving Technical Energy Efficiencies 37
Housekeeping Measures, Renovations and Retrofitting 38
Improving Process Technology 38
Spatial Issues 40
Improving the Efficiency of Capital Goods 41
C. Improving the Efficiency of Electricity Use 42
Overview of the Potential for Improvement 42
Reducing Power System Losses 44
Increasing the Efficiency of Electricity End-use 46
Electric Lighting 46
Electric Motors and Associated Equipment 46
High-Frequency Electric Furnaces 49
Home Appliances 50
Air Conditioning 50
D. Improving the Efficiency of Coal Use 51
Improving Efficiencies in Industrial Boilers 51
Improving Coal Quality 53
Improving Coal Utilization in the Household Sector 54

4 The Policy Framework for Energy Conservation 56

A. China's Current Energy Conservation Policy Framework 56
Essential Features of the Current System 57
Advantages of the Current System 58
Disadvantages of the Current System 59
B. Market-Based Energy Conservation Programs 61
C. Issues and Options for the 1990s 63
Energy Price Reform 65
Energy Supply Quotas and Unit Consumption Standards 67
Promotion of Improved Technology and Strengthening Energy-Efficiency Standards for New Equipment 68
Strengthening Technical Assistance and Training 70
Improving Appraisal Criteria for Energy Conservation Investments 70

TABLES IN TEXT

1.1	Energy Balance, 1990	2
1.2	International Comparisons of Energy/GDP Growth Elasticities, 1966-90	5
1.3	Commercial Energy Consumption Growth by Sector, 19‿‿-90	6
1.4	International Comparisons of Primary Energy Consumption Relative to GDP, 1980-88	7
1.5	International Comparisons of Total Final Energy Consumption Per Unit GDP, 1988	9
2.1	Changes in Commercial Energy Intensity Relative to National Income, 1981-90	14
2.2	Estimated Sources of Commercial Energy Savings Relative to Real National Income, 1981-90	15
2.3	Total Commercial Energy Savings by Economic Sector, 1981-90	17
2.4	Sectoral Shares of Real National Income, 1980-90	18
2.5	Energy Savings due to Change in the Structure of Major Production Sectors, 1981-90	19
2.6	Reductions in Sectoral Energy Intensities, 1981-90	21
2.7	Energy Use and Intensity by Industrial Subsector, 1985-90	23
2.8	Estimated Net Imports of Embodied Energy in Energy-Intensive Industrial Products	25
3.1	Changes in Unit Energy Consumption for Selected Industrial Products in the 1980s	32
3.2	International Comparisons of Energy Use for the Production of Selected Industrial Commodities	34
3.3	Estimated Economically-Viable Potential for Improving Electricity Efficiency	43
3.4	Comparison of Chinese and US Electric Motor Efficiency Ratings	48
4.1	Comparison of Chinese and International Energy Prices, 1991	66

FIGURES IN TEXT

2.1	Annual Change of the Share of Industry in National Income	20
2.2	Energy Savings Due to Changes in the Sectoral Structure	20

ANNEXES

1. Statistics on China's Energy Consumption in International Perspective

Table 1: 1990 Commercial Energy Balance Sheet
Table 2: 1988 Commercial Energy Balance Sheet
Table 3: International Comparisons of the Share of Electricity in Final Energy Consumption, 1988
Table 4: International Comparisons of the Composition of Final Energy Consumption, 1988
Table 5: International Comparisons of Per Capita Final Energy Consumption, 1988
Table 6: International Comparisons of Per Capita Final Electricity Consumption, 1988
Table 7: International Comparisons of Per Capita Final Consumption of Nonelectricity Fuels, 1988
Table 8: International Comparisons of the Composition of Final Electricity Consumption, 1988
Table 9: International Comparisons of the Structure of GDP, 1988
Table 10: International Comparisons of Energy Intensities in Industry and Agriculture, 1988
Table 11: International Comparisons of the Structure of Mining and Manufacturing Gross Output Value, 1990 and 1988

2. Statistics on China's Energy Consumption and Conservation during the 1980s

Table 1: Annual Final Commercial Energy Consumption, 1980-90
Table 2: Annual Final Electricity Consumption, 1989-90
Table 3: Annual Energy Savings Relative to Total National Income, 1981-90
Table 4: Total Energy Savings Relative to Total National Income, Sixth and Seventh FYP
Table 5: Structure of National Income and Energy Savings due to Structural Change in Major Production Sectors, 1980-90
Table 6: Energy Use Per Unit Contribution to National Income, 1980-90
Figure 1: Basic Materials and Industry Growth Index, 1981-90

3. China's Institutional and Policy Framework for Energy Conservation

Table 1: An Example of an Energy Conservation Project Financing Package

EXECUTIVE SUMMARY

Introduction

i. Improving energy efficiency is recognized in China and worldwide as an issue of strategic importance in China's development. The increasing need for energy services to sustain continued rapid economic development can be provided only through a balanced combination of increases in energy supply and improvements in the efficiency of energy use. This is true not only from the economic perspective, but also from an environmental point of view: improvements in energy efficiency are at the core of efforts to reduce air pollution and greenhouse gas emissions.

ii. The purpose of this study is to provide a broad overview of energy efficiency issues in China. It includes a review of macroeconomic energy intensity trends and the factors underlying them, and an assessment of priority areas for energy conservation initiatives and policy reform. The primary focus is on the industrial sector, which dominates commercial energy use. Electricity conservation was a special focus in the fieldwork. The study focuses mainly on strategic issues; more in-depth analysis of investment priorities is being undertaken as part of ongoing and planned follow-up work.

Energy Efficiency and Reform of China's Economic System

iii. Unquestionably, China's ability to achieve further, major and sustained success in reducing the energy intensity of the economy rests on continued progress in economic system reform. Increasing the market orientation of the economy, enterprise reform leading to a hardening of state enterprise budget constraints, further progress in price reform, and financial sector reform are all central to China's efforts to improve the efficiency of use of all resources, including energy. The extent to which changes in macroeconomic structure will continue to provide major energy savings will ride largely upon the extent of progress in economic reform (see paras. xvi-xviii below). Continued, serious improvements in technical energy efficiencies also will require fundamental improvements in the economic environment which defines enterprise incentives to use energy-efficient technology (paras. xxvii-xxxviii below).

iv. Specific energy conservation programs and policies also have an important role to play. In China, as in many other countries, however, there is at times a tendency to lose proper perspective. At times, the role of specific programs to increase awareness of energy conservation issues, to provide technical assistance, and to support specific energy conservation investments is overemphasized, and may to some extent cloud the importance of making progress on underlying fundamental issues affecting energy efficiency. The best role of the specific energy conservation initiatives is a supplemental one: to build upon and further sharpen broader, more implicit forces developed through system reform to improve the efficiency of use of energy and other materials.

Energy Efficiency and the Environment

v. Improvements in the efficiency of energy use are probably the most important single means to brake China's growing problems of air pollution and greenhouse gas emissions.

Given the dominance of coal in energy use, achievement of energy efficiency gains as discussed in this report—involving macroeconomic structural change, industrial modernization, and specific technical improvements—takes on added urgency as a key component of the country's environmental strategy.1/

vi. In addition to the direct positive impact of reductions in energy consumption on the environment, energy efficiency gains and environmental protection also are intertwined in that policy and technical prescriptions for progress on both fronts are often the same, or at least highly related. The macroeconomic structural effects which lead to declines in energy intensity also tend to lead to declines in the intensity of use of other natural resources and to lower emissions of other, nonenergy-related pollutants (para. 2.55). Technical improvements yielding energy efficiency gains also often yield environmental gains over and above those derived from the use of less energy, especially in cases involving broad industrial modernization and process technology changes. This further strengthens the case for further close interaction between agencies involved in energy conservation and those involved in environmental protection.

Summary of Past and Prospective Energy Intensity Trends

vii. **China's High Energy Intensity.** Primary energy consumption per unit of Gross Domestic Product (GDP) in China is high, compared to most other countries. China's high energy intensity is caused both by factors having to do with macroeconomic and energy consumption structure, and by technical inefficiencies. One "natural" structural factor is China's high residential sector energy use per unit GDP. This exists in all low-income developing countries (paras. 1.9-1.11 and 1.23-1.24). Other important structural factors stem from the economic development path chosen by China. The relatively high share of industrial output in China—46 percent of GDP in 1988—leads to high energy intensity because industry is far more energy-intensive than agriculture or services. Chinese industry also is dominated by the production of basic, intermediate industrial goods, and generally low levels of product quality or specialization. This creates low levels of value-added per unit energy, compared with more mature industrial economies (paras. 1.27-1.29).

viii. Out-of-date, energy-inefficient technology remains pervasive. Energy consumption per physical unit of output of major energy-intensive products is still some 30-100 percent higher in China than in more developed countries. Efficiency penalties associated with the dominance of solid fuels (coal and biomass) are a contributing factor. Continuing poor energy management practices in some areas is another. The most important technical factor, however, is the type of technology that has been employed. At issue is not only the relatively backward technical levels of older plants still in production, but also the choice of technology for the very large amount of new capacity added during the 1980s (paras. 3.11-3.18).

ix. **Trends in the 1980s.** China's commercial energy intensity per unit GDP fell by over 30 percent between 1980 and 1990—a remarkable achievement by international standards. The elasticity of growth in commercial energy use relative to GDP growth was just 0.5. Commercial energy savings resulting from this decline in energy intensity totaled over 300 million tons of coal equivalent (TCE) by the end of the decade, which was almost as much as the increase in domestic commercial energy supply (346 million TCE).

1/ See The World Bank, *China: Environmental Strategy Paper*, 1992.

x. Structural factors were the most important causes of the decline in energy intensity, accounting for some 55-65 percent of the total energy savings over the period. Improvements in physical energy efficiencies accounted for the remaining 35-45 percent. Among the largest energy-intensive industries, the most impressive gains were made in the steel industry, where unit energy consumption fell by over 20 percent between 1980 and 1990 (paras. 2.8-2.13 and 3.4-3.5). Government-sponsored programs to improve energy management, promote widespread adoption of energy "housekeeping" measures, and replace outmoded equipment have played an important role in achieving these gains (paras. 3.6-3.9).

xi. **Outlook for the 1990s.** China's development targets call for a further reduction in commercial energy intensity per unit GDP of at least 20 percent between 1990 and 2000. This corresponds to an elasticity of growth in commercial energy use relative to GDP growth of 0.6. The further requisite energy savings can be achieved, but pose a major challenge. Success will require both further substantial structural savings and an acceleration in technical energy efficiency gains over the slow rates of improvement observed in many subsectors during the last few years.

Issues of Macroeconomic Structure and Energy Intensity

xii. Changes in macroeconomic structure were the leading cause of the slow growth in China's energy demand relative to growth in GDP during the 1980s. These structural factors can continue to play a critical role in reducing energy intensity levels in the future. The magnitude of these future energy savings from structural factors, however, will be closely tied to the rate of progress in economic system reform.

xiii. Structural factors accounted for about 70 percent of the decline in energy intensity achieved during the Sixth Five-Year Plan (FYP, 1981-85). The major factors included (a) slow growth in residential sector energy use and energy industry losses, relative to the growth in national income, (b) increases in the imports of key energy-intensive industrial goods, and (c) changes in the mix of industrial products domestically produced.

xiv. The overall rate of decline in China's energy intensity slowed to about 2.8 percent per year during the Seventh FYP (1986-90), compared to the rate of 4.8 percent per year achieved during the Sixth FYP. The major reason was that the net energy savings from the combined influence of all structural factors fell sharply from about 120 million TCE during the Sixth FYP to some 45-80 million TCE during the Seventh FYP. This has caused some Chinese energy analysts to conclude that the potential role of structural factors in reducing China's energy intensity is waning. Further analysis conducted in this study (paras. 2.8-2.44), however, shows that key structural factors worked against each other during the Seventh FYP, to some extent canceling each other out:

(a) Although the share of industry in national income in terms of current prices actually fell, the share of industry in *real* national income rose sharply between 1985 and 1990, producing a strong pressure towards *greater* energy intensity, and major "negative" energy savings.

(b) Net imports of key energy intensive products *fell* during the period, in reverse of the trend during the Sixth FYP, creating an additional source of substantial "negative" energy savings, as domestic production of these products increased accordingly.

(c) These two sources of negative savings largely obscure the major positive effect which other, nontrade-related changes in the industrial product mix had on reducing energy intensities. Energy savings here accelerated during the later part of the 1980s. Indeed, this factor alone is estimated to have produced energy savings more than twice as large as the total savings achieved through all technical improvements during the Seventh FYP.

xv. The mission concludes that potential for major energy savings from structural factors remains, because the factors creating negative savings above should diminish, but great potential remains for other factors to continue to provide major positive energy savings.

xvi. Reviewing the outlook for the future, there are some structural effects which are expected to continue to produce energy savings, but have little to do with government policy. These include:

(a) **The "Residential Sector Effect."** Over the long term, continued substantial energy savings can be counted on from slower growth in residential energy use relative to growth in GDP, following well-established trends for developing countries. Total residential energy use is expected to grow slower than GDP despite very rapid growth in household electricity use (paras. 2.16-2.18).

(b) **Slower Growth in Energy Industry Losses.** Growth in energy production at slower rates than GDP growth, due to energy savings from other factors, will produce some modest energy savings through slower growth in energy industry losses, relative to national income (para. 2.19).

xvii. Other structural effects, however, are tied to underlying trends of economic development, the progression of which is influenced by macroeconomic policies. These include:

(a) **The Sectoral Distribution of Economic Output.** The key issue here for the 1990s is the relative roles of the industrial and services sectors. If real industrial net output grows at the same rate as GDP, and faster growth in the service sector makes up for the expected slower growth in agriculture, the major counterbalancing effect on energy savings of the increasing share of industry over the Seventh FYP would be eliminated (paras. 2.20-2.22).

(b) **Trade in Energy-Intensive Products.** The sharp decline in net imports of energy embodied in industrial products of the Seventh FYP, which produced substantial negative energy savings, is not expected to continue during the 1990s. Steel imports, for example, have already fallen far from the peak levels of the mid-1980s (paras. 2.32-2.34).

(c) **Nontrade Changes in the Industrial Product Mix.** Potential continues to exist for major energy savings through changes in the mix of products produced by Chinese industry. Key issues include: (i) improvements in the efficiency of use of energy-intensive commodities, such as steel and cement, in other industries and sectors, (ii) increases in industrial value-added from greater product diversification and specialization, (iii) increases in value-added from improvements in product quality. This process of maturing in China's industrial sector is a long-term process. However, further policy reform in support of greater competition, cost-consciousness and profit-seeking among enterprises would provide a major boost in this direction, and a corresponding key source of energy savings over the medium term (paras. 2.35-2.44).

xviii. Effects (a) and (c) above—changes in the sectoral distribution of economic output and nontrade-related changes in the industrial product mix—are by far the most important structural effects in terms of the size of their influence on total energy intensity. The future role of both factors, but especially declines in energy use per unit value-added through improvements in product quality and other changes in the industrial product mix, depend largely upon further progress in wide-ranging reforms to improve overall economic efficiency. The two effects are interrelated, as increases in product diversification and technological sophistication tend to require expansion of service sector inputs.

Improving Technical Energy Efficiencies

xix. The importance of structural factors does not in any way detract from the importance and urgency of efforts to improve technical energy efficiency, both from macroeconomic and microeconomic perspectives. With the development of an extensive institutional and administrative system for promoting energy conservation initiatives, China made notable progress in reducing unit energy consumption levels across the economy over the last decade. The mission was favorably impressed by the success achieved so far in widespread promotion of rudimentary energy management practices, energy "housekeeping" measures, and a variety of retrofitting projects. However, large gaps remain between energy efficiency levels in China and international norms. Broad estimates indicate that attainment of efficiency performance levels of the developed countries today would result in total energy savings of about one third of total current consumption (paras. 3.4-3.17).

xx. **Energy Efficiency and Industrial Modernization.** Although further efforts to promote improved energy housekeeping and retrofitting projects remain important, there is a critical need to balance this thrust with more effort on modernizing the basic industrial technology employed. The fact is that too much of the *new* capacity added during the later 1980s is well below international efficiency standards. This is due both to continued deployment of out-of-date technology and plant scale which is too small to properly capture scale economies. During the boom years of the middle 1980s, it may have been easiest to meet rapid demand growth through less capital-intensive, smaller, and more rapidly gestating projects, using technology that was familiar. However, this now carries long-term penalties in terms of high recurring costs and high energy consumption rates for what is often a low-quality product. If major energy efficiency gains are to be made in the future, the required up-front investments must be made in modern, high-efficiency capacity of suitable scale.

xxi. There also is a need for a more critical and aggressive approach to restructuring some of China's older, particularly out-of-date capacity. Promotion of marginal energy conservation projects can be a waste of resources in such cases, where major changes or plant closure may be more appropriate.

xxii. To best realize the potential for energy efficiency gains, comprehensive energy conservation strategies should be developed and implemented as part of the overall modernization programs for the principal energy-intensive subsectors. The strategy should explicitly include (a) transfer and/or adaptation of modern international process technology, especially for new capacity, (b) priority energy conservation initiatives to improve the efficiency of mainstream existing capacity and processes, and (c) industrial restructuring to eliminate (or transform) the most inefficient elements of existing capacity (paras. 3.18-3.31).

xxiii. Given the investment and technology transfer requirements, international assistance is important in this area. Although they include other goals as well, programs to provide support for restructuring and modernizing key industrial subsectors are especially significant means to foster improvements in energy efficiency in China.

xxiv. **Improving the Efficiency of New Equipment.** The Government has increased emphasis on improving the energy efficiency of the energy-using equipment produced by Chinese industry in recent years. These efforts are vital and need to be strengthened and expanded. Although other types of equipment are also important, two particularly significant areas are industrial boilers and electrical machinery such as motors, pumps and fans. Because a widespread and lasting impact can be made through a relatively focussed effort, programs to improve the efficiency of new equipment are strategically attractive. Special efforts need to be made to (a) encourage transfer of foreign technology, especially through joint-venture production, (b) provide investment and policy support for putting the best items into mainstream, mass production, (c) implement rigorous quality control, so as not to undermine consumer acceptance, and (d) ensure that relative prices for different models of the same equipment are not biased *against* the more efficient models solely because they are new, and hence subject to less control (paras. 3.34-3.36 and 4.49-4.50).

xxv. **Integrated Industrial Energy Supply and Cogeneration.** Major gains can be made in energy efficiency and environmental protection in dense industrial areas, through development of centralized heat, steam, gas and/or cogeneration facilities. Further expansion of industrial cogeneration with single-enterprise steam supply is an area where great potential remains. More ambitious integrated schemes also deserve support, but on a case-by-case basis, as development is complicated by issues of flexibility, equitable pricing, and institutional coordination (paras. 3.32-3.33).

xxvi. **Priority Programs in Electricity and Coal Conservation.** Much of the nation's energy conservation work should focus upon process technology and other industry-specific technical improvements, best undertaken as part of overall industrial subsector modernization programs, as discussed above. In addition, there are more generic types of initiatives. Below, the mission singles out four areas concerning electricity and coal conservation where priority action is especially warranted.2/ Although a wide range of additional activities are worthwhile, and should be undertaken (paras. 3.37-3.86), the areas below have particularly large potential for economically viable energy savings.

2/ In the fieldwork, the mission put special emphasis on electricity conservation. Concerning the efficiency of coal use, the mission has drawn largely upon previous work (see The World Bank, *China: Efficiency and Environmental Impact of Coal Use*, 1991). Issues relating to the efficiency of petroleum products deserve future, detailed review.

(a) **Reduction of Power System Transmission and Distribution Losses.** Some 16-20 percent of China's power generation is lost in the transmission and distribution system, compared to losses of 10-12 percent in most developed country systems. Losses in rural areas, which account for about one third of national power consumption,3/ are reported at a very high 33 percent. The reduction of losses will require expanded, but economically attractive, investment for network renovations, for replacement of technologically backward transformers and other substation overhauls, and for addition of capacity to improve system power factors (paras. 3.41-3.48).

(b) **Improvements in the Efficiency of Electric Motors and Associated Equipment.** About two thirds of China's total final electricity use is to drive electric motors. This includes free-standing motors as well as motors integrated into pumps, fans and other machines. Although a number of actions are worthwhile, the mission feels that priority should be given to further improvements in the efficiency of motors currently produced, and expanded use of both improved fixed-speed and variable-speed motors in the production of key types of industrial equipment. Immediate steps required include completion of (i) an assessment of the potential for introducing true high-efficiency motor designs from abroad into Chinese production, and (ii) a market survey for motors and associated equipment (paras. 3.52-3.60).

(c) **Improvements in the Efficiency of Coal-Fired Industrial Boilers.** China's current stock of 400,000 industrial boilers currently account for about one third of coal use. Actual operating efficiencies average 55-60 percent, compared to 75-80 percent in modern coal-fired boilers internationally. Key factors include small scale (85-90 percent of the boilers have capacities under 6 tons per hour), lack of modern efficiency design features, poor quality manufacturing, poor operation practices, and low fuel quality. A stronger effort to adapt modern technology for improved boiler designs to the needs of the Chinese market is urgently needed, followed by an effort to make higher-efficiency units widely available to consumers. Immediate steps required include completion of (a) an in-depth evaluation of the characteristics of future boiler demand, and (b) a detailed evaluation of options to improve boiler efficiency, based on both domestic and international research and experience, focusing on the 2-20 ton/hour size range (paras. 3.68-3.74).

(d) **Improvements in Coal Quality.** Coal quality problems greatly contribute to inefficient coal use in boilers and other applications. Much of the problem stems from unpredictable fluctuations in the type of coal supplied, lack of sizing or screening, and the use of fines in inappropriate applications. The principal constraints to improvement are not technical ones. Problems lie primarily with the nature of the coal allocation system and current pricing practices. As the country moves ahead with coal price reform, special attention is due to the issue of how to improve and stabilize coal quality through reform of the coal

3/ County-run industry located in rural areas is included as rural consumption in this estimate.

allocation and marketing system, and selected investments in associated infrastructure (paras. 3.75-3.77).

Strengthening Energy Conservation Policies

xxvii. The greatest single problem in the country's energy conservation program is that enterprise incentives to use energy efficiently remain inadequate. A fundamental improvement in incentives will require widespread economic reform, especially reforms designed to increase the autonomy and accountability of state enterprises This is outside the scope of direct concern of energy conservation policymakers. However, major improvements also can be made through energy price reform and other measures to better attune China's existing policies for promoting energy conservation to the needs of the evolving, more market-oriented, new economic environment.

xxviii. **Advantages and Disadvantages of the Current Framework.** During the 1980s, China successfully developed a comprehensive energy conservation program, including major policy directives, procedures, regulations, technical assistance programs, and project financing initiatives. Compared to programs in other developing countries, China's program is especially strong in its comprehensive coverage of enterprises, monitoring of consumption practices, promotion of awareness of energy efficiency goals among enterprise managers, and domestic information dissemination. Efforts to improve energy efficiency have become a more integral and serious aspect of the energy planning process in China than in most developing countries. These strengths stem from the government's successful efforts to build up an institutional framework for overseeing and implementing energy conservation work. This framework consists of a series of national, provincial and county/municipal-level government units (see paras. 4.3-4.10 and Annex 3).

xxix. Built largely upon planned economy concepts, the existing system emphasizes administrative measures to prod enterprises to improve energy efficiency. Clearly, there are many cases where strong incentives for energy conservation have resulted. The problem is that, despite elaborate fine-tuning efforts, the administrative measures are too crude to consistently stimulate proper enterprise responses. A natural drawback with many of the measures is that they are not "automatic," or built into the economic system. Administration is difficult and complicated. The pressure applied to enterprises is greatly uneven, and for reasons that are arbitrary from an economic point-of-view. This creates serious distortions. In addition, the current system encourages mediocrity, rather than promotion of optimal efficiency levels. As performance evaluation tends to be referenced against domestic averages, conspicuous waste is discouraged, but there is a tendency towards marginal modification of prevailing, relatively energy-inefficient industrial technology (even for new capacity), rather than more bolder adoption of new approaches or processes (paras. 4.11-4.20).

xxx. Much of the energy conservation promotion system built up through the 1980s will serve China well in the future; the institutional network, and its increasing capacity to execute serious energy conservation initiatives on a comprehensive scale, provide a critical advantage. Some of the administrative measures which have been relied upon heavily in the past, however, cannot be expected to work effectively or efficiently in a more market-oriented future. Greater emphasis is needed on policy tools that work in coordination with and complement market forces. The mission's chief recommendations are outlined below. The mission hopes that these observations will be considered in the preparation of the proposed new Energy Conservation Law.

xxxi. **Energy Price Reform.** Further, major reform of energy prices is essential for the nation's energy conservation program to be effective. While progress has been made in increasing price levels, especially at the margin, the progress to date is insufficient. Reforms must include both substantial increases in price levels for in-plan supplies, and rationalization of the price structure. Reforms should include pricing for electricity, petroleum products and gas, but especially pricing for coal. A large portion of China's coal is still sold at in-plan prices which are based on ex-mine prices equivalent to about one half of the actual long-run marginal cost of production. This sends false, distorted signals to key consumers that there is little real purpose or benefit to energy conservation.

xxxii. In-plan energy prices must better reflect actual costs if the enterprises which benefit from them are to undertake increased investment in more efficient process technology, in high-efficiency equipment, and in major retrofitting projects. Currently, many types of investment which are attractive to the nation are not financially viable for those enterprises receiving in-plan energy supplies. As is well recognized, supplies of subsidized funding for such projects cannot come close to filling the gap—the bulk of funding must be arranged by enterprises themselves.

xxxiii. In addition, the complexity and lack of transparency of the existing multiple tier pricing systems, especially for electricity, also erodes interest in investments in energy efficiency. Where energy costs in the future are difficult to define and/or subject to uncertainty, this greatly and unduly adds to the risk of investments to save on future energy costs. This is one among many reasons why simplification and unification of energy prices is also necessary (see paras. 4.35-4.43 and the additional studies and documents listed there).

xxxiv. **Energy Supply Quotas and Unit Consumption Standards.** Movement towards unified prices and a greater role of the market will naturally reduce the applicability and usefulness of energy supply quota manipulation as a policy tool to promote energy conservation. In addition, the role of unit energy consumption standards in the future program should be carefully considered. These standards are useful as (a) reference points for factory managers and local officials as to how the unit consumption patterns of enterprises compare, and (b) a tool to identify "outlier enterprises" with dramatically inefficient use patterns, compared with others. However, these crude tools cannot be relied upon to properly encourage enterprises to reach their true energy efficiency potential. Over the short term, it may be necessary to continue to use these standards as a component of the system of administrative measures to promote energy efficiency, especially among large- or medium-sized state enterprises. However, this should be considered as transitory. The mission strongly recommends that the government *not* endorse a policy to rely on mandatory unit energy consumption standards for enterprises as a central tool to try to provide greater enterprise incentives for energy savings. Such a policy would be without precedence internationally (for good reasons), and would run counter to the spirit of other reforms (paras. 4.44-4.46).

xxxv. **Energy-Efficiency Standards for New Equipment.** The current system of setting and enforcing energy-efficiency standards for new equipment should be improved and strengthened, to better fulfill its function to encourage industries to improve the energy efficiency of mainstream equipment models. The mission recommends that true energy-efficiency standards be applied only for a selection of key equipment types, but where used, application should be mandatory and rigorous. The standards should be practical and clear for the industries concerned, and these industries should continue to be closely involved in the formulation process. Pricing policies for the equipment types covered should be explicitly reviewed as part of the process of developing specific standards, in order to ensure that state price regulations are consistent with the energy-efficiency objectives of the standards. It also would be useful for the process of developing, applying and enforcing energy-efficiency standards for equipment to be legitimized in the proposed Energy Conservation Law (paras. 4.47-4.51).

xxxvi. **Strengthening Technical Assistance and Training.** China has successfully built up capacity to provide enterprises with technical assistance and training in energy management and conservation. Given the enormity of the country's needs, however, further expansion and improvements in the energy auditing and training programs are still urgently required. There are needs to expand both basic energy management training and more detailed technical training catering to specific industries or types of technologies. Stronger programs are needed for smaller enterprises, including township and village industries. In addition, energy conservation service centers need increased supply of measuring equipment and related instrumentation needed to properly conducting energy audits on the scale required (paras. 4.52-4.53).

xxxvii. **Appraisal Criteria for Energy Conservation Investments.** Greater attention needs to be given to financial and economic return criteria in the allocation of state funds dedicated for energy conservation projects. To improve the project selection process, the mission suggests that relevant Chinese agencies (a) use the current gross investment per TCE of energy savings concept only to establish a minimum requirement which all projects must meet to obtain funding from the dedicated facilities, and then (b) use economic rate-of-return criteria (complemented with additional, quantified environmental analysis, where necessary) to select the best projects from the pool of projects that meet the minimum energy-savings requirement (paras. 4.54-4.58).

xxxviii. The mission also observed a number of cases where the existing broad guideline to utilize 20 percent of enterprise depreciation funds for energy conservation investments was being applied by local agencies as a regulation for individual enterprises. This practice is irrational from an economic point-of-view, and must be discouraged (para. 4.59).

Priorities for Follow-up Action

xxxix. The following table presents the mission's recommendations on the next steps which should be taken to strengthen China's energy conservation effort, in line with the broad findings of this study. This has been used as a basis for discussions between the Bank and the government on follow-up to this report.

xl. **The Role of the World Bank.** Follow-up technical assistance and preinvestment work on energy conservation in China is organized under a major Chinese/Bank study supported by the Global Environment Facility (GEF), "China: Issues and Options for Greenhouse Gas (GHG) Emissions Reduction." Special focus is given in this study to detailed subsector-by-subsector analysis of technical options and their relative benefits and costs. Preinvestment studies on improving industrial boiler efficiency and urban residential and commercial sector coal use also are included. Additional follow-up also is being undertaken through the World

Bank/UNDP Energy Sector Management Assistance Programme (ESMAP), including a much-needed rural power system loss reduction technical assistance initiative.

xli. The Bank also is expanding support for energy conservation through lending operations. Options include continued support through industrial lending, support as part of energy sector projects (e.g., as in the proposed Sichuan Natural Gas Development and Conservation Project), and support through stand-alone operations.

PROPOSED FOLLOW-UP ACTION PLAN

Recommended action	Responsible agencies
Policy	
1. **Reform energy price levels and structures.** Immediate action is required to (i) implement increases in in-plan prices for energy (especially coal) to levels reflecting economic costs over three years or less, and (ii) implement action programs to unify and simplify all energy prices.	SPC, General Price Bureau, State Council
2. **Expanded assessment of indirect, structural energy savings.** The energy conservation value of projects which provide major indirect energy savings should be explicitly recognized (quantified, where possible) in review of investment projects. A comprehensive evaluation of structural energy savings during the Seventh FYP and implications for the 1990s should be completed by the Energy Research Institute (ERI) of SPC.	SPC/State Economic and Trade Office (SETO), ERI
3. **Prepare an energy conservation policy transition plan.** A medium-term strategy should be prepared by core government agencies on how to make the transition from reliance on administrative measures to create pressure for enterprises to save energy to greater reliance on measures which complement and build upon market forces.	SPC/SETO
4. **Strengthen energy efficiency standards for new equipment.** The first step should be to evaluate the level (in international perspective), and actual application and efficacy of existing standards for key equipment such as boilers and electrical machinery. This should be followed by the design and implementation of a program to strengthen the standards and their application, so as to achieve efficiency levels for new equipment comparable to those abroad.	SPC/SETO/National Bureau of Technical Control/line ministries
5. **Strengthen training and technical assistance capabilities.** The existing network of energy conservation service centers needs to be further expanded and strengthened to expand coverage among smaller enterprises, and to improve the quality and depth of auditing and training.	SETO/Provincial governments
6. **Improve appraisal methodology for energy conservation investments.** The first step is to design improved, practical methods to improve financial and economic assessments, and to apply them on a trial basis for a number of projects under the GEF GHG study.	SPC/SETO/ERI/State Energy Conservation Company
Preinvestment/Investment	
7. **Prepare energy efficiency strategies for energy-intensive industrial subsectors.** With support through the GEF GHG study and other donor projects, these need to include strategies to improve process technology and for subsector restructuring to eliminate or transform the most inefficient existing capacity, as well as priorities for renovation investments.	SPC/SETO/line ministries
8. **Strengthen efforts to reduce power system losses.** An action program should be developed with support under the GEF GHG study and an ESMAP program for rural power grids to expand investment in (i) measures to reduce station losses, (ii) power factor correction, (iii) transformer replacement, and (iv) distribution network overhaul.	Ministries of Energy (MOE) and Water Resources (MWR)
9. **Implement a program to improve the efficiency of electric motors and associated equipment.** Initial technology assessments, market surveys, and identification of investment priorities are being conducted through the GEF GHG study.	SPC/SETO/Ministry of Machinery and Electronics Industries (MMEI)
10. **Implement a program to improve the efficiency of new coal-fired industrial boilers.** The first steps are being undertaken through the GEF GHG study, including a boiler market survey, an evaluation of options to improve boiler design and manufacturing, and review of investment options.	SPC/SETO/MMEI
11. **Evaluate opportunities to improve the efficiency of coal use through improvements in the allocation/marketing system.** Concrete demonstration projects need to be developed to improve the matching of coal varieties and sizes to meet consumer requirements through reform of the allocation and marketing system and selected investment in associated infrastructure.	SPC/SETO/MOE
12. **Expand development of integrated energy supply systems for industrial parks.** The initial step is to complete detailed feasibility studies and rigorous financial/economic analysis for a small number of demonstration projects.	SPC/SETO/local governments
13. **Expand industrial cogeneration capacity.** The first step is to conduct a study to evaluate the potential for expanded, economically viable development within the various subsectors, to identify existing constraints inhibiting development, and to analyze options to alleviate these constraints.	SPC/SETO/MOE

1
THE ENERGY INTENSITY OF CHINA'S ECONOMY

A. ENERGY CONSUMPTION PATTERNS IN CHINA

1.1 China is the third largest energy consumer in the world, following the US and the former Soviet Union. China's total energy consumption of 1,245 million tons of coal equivalent 1/ (872 million tons of oil equivalent) in 1990 was much higher than any other developing country. Including biomass fuels, China's consumption was about three times India's, five times Brazil's, and almost twelve times South Korea's.

1.2 China leads the world in coal use, as consumption passed the one billion ton mark in 1989. China also leads the world in consumption of biomass fuels. Chinese farmers currently burn an estimated 284 million TCE of fuelwood, crop residues and other biomass, which is roughly 60 percent higher than the consumption level of India, the next largest consumer. China electricity consumption of 623 TWh in 1990 ranked fourth in the world.

1.3 Energy use patterns in China in many ways reflect its unusual status as a low-income developing country with an extensive industrial sector. The national energy balance for 1990 presented in Table 1.1 shows a blend of energy use patterns that are typical for low-income developing countries with patterns that are more characteristic of industrialized middle-income developing countries or developed countries. In addition, China's energy balance is noteworthy for the high share of solid fuels in primary energy consumption. Coal and biomass fuels together account for 81 percent of primary energy use.

1/ "Standard tons of coal equivalent" (TCE) are used as the basic energy unit in analysis of Chinese energy use patterns throughout this report, in order to conform with Chinese practice. A TCE is defined as 7 million kilocalories. One TCE is thus equivalent to 7/10 of a ton of oil equivalent. A TCE is different from a ton of coal, because the calorific values of coal vary substantially. Chinese coals typically have calorific values in the range of 4,500-6,500 kilocalories per kilogram. Accordingly, a ton of Chinese coal is typically equivalent to 0.65-0.95 TCE. *The energy accounting of electricity in this report also varies from standard international practice.* At all stages (final as well as primary energy consumption), electricity is converted into TCE based on its thermal replacement value. This also is standard Chinese practice, and it provides a number of distinct advantages in analyzing energy efficiency issues in a country where thermal power production dominates. The thermal replacement value is the average amount of energy used to produce a kilowatt-hour of electricity in thermal power production. This is roughly three times the heating value of electricity (860 kilocalories per kWh), which is commonly used elsewhere, at least for final consumption. International figures used in this report have been recalculated, where necessary, based on the thermal replacement value for China in 1988 of 2,780 kilocalories per kWh. The energy value for electricity used in analysis of Chinese consumption trends in this report and Chinese studies also varies by year, following increases in the average energy efficiency of thermal power production.

Table 1.1: ENERGY BALANCE, 1990
(million tons of coal equivalent)

	Coal	Oil	Gas /a	Power	Total Commercial Energy	Biomass	Total Energy
Primary Energy Production	771.8	197.6	20.3	49.7	1,039.4	284.0	1,323.4
Net trade	-13.0	-33.6	-	0.7	-45.9	-	-45.9
Change in inventory	-31.6	-0.6	-	-	-32.2	-	-32.2
Total Primary Energy Use	727.2	163.4	20.3	50.4	961.3	284.0	1,245.3
Power generation	-174.8	-17.6	-1.5	193.8	0.0	-	0.0
Power station & transmission losses	-	-	-	-33.8	-33.8	-	-33.8
Other conversions and losses	-30.6	-11.9	15.6	-	-27.0	-	-27.0
Statistical discrepancies	24.7	0.7	0.0	0.0	25.4	-	25.4
Total Conversion and Losses	-180.7	-28.8	14.1	160.0	-35.4	-	-35.4
Agriculture	16.7	9.0	0.0	16.7	42.4	-	42.4
Industry	356.7	57.5	28.5	157.2	599.9	-	599.9
Construction	3.4	2.6	1.4	2.5	10.0	-	10.0
Transport/communication	16.5	48.8	0.1	4.2	69.5	-	69.5
Commerce	8.2	0.3	0.1	3.0	11.6	-	11.6
Public sector (nonproduction)	15.3	11.2	0.3	7.9	34.7	-	34.7
Urban residential	70.4	3.8	4.1	10.7	89.0	-	89.0
Rural residential	59.5	1.4	0.0	8.2	69.0	284.0	353.0
Total Final Energy Consumption	546.5	134.5	34.4	210.4	925.8	284.0	1,209.8

/a Includes both natural and manufactured gas. Excludes liquefied petroleum gas, which is included under oil.

Source: Annex 1, Table 1.

The Role of Different Fuels

1.4 Coal dominates China's primary energy use, accounting for 58 percent of total energy use and 76 percent of commercial energy use in 1990. About 24 percent of the coal was used in power generation, while almost all of the remainder was used directly. The massive consumption of coal as a direct fuel in industry and residences is a central, but unique, aspect of China's energy economy. Coal use accounts for about 59 percent of industrial energy consumption, and an exceptionally high 79 percent of urban household energy use. Coal is even important in the transport sector, where its use in steam railway locomotives brings the share of coal consumption to over one quarter of that sector's energy use.

1.5 Biomass fuels accounted for an estimated 23 percent of total energy use in 1990. Fuelwood, consisting primarily of low-quality brush and branches, provided some 138 million TCE in 1989. Crop residues provided a similar amount (an estimated 136 million TCE), and a small amount of dried dung was also burned (3 million TCE in 1989).2/ Biomass accounts for a lower share of total energy consumption in China than in most other developing countries. In India, the share of biomass fuel is about 45 percent, and in many African countries, the share exceeds 80 percent. The relatively low share in China is due primarily to the size of industrial commercial energy consumption and the fact that biomass fuels are used virtually exclusively by rural households. Per capita levels of biomass fuel use by rural households is of the same order of magnitude as in other low-income countries.

1.6 Oil accounts for a relatively low share of consumption, especially compared with most middle-income or developed countries. In 1990, oil accounted for 13 percent of total energy and 17 percent of commercial energy use. China is, however, a net oil-exporting nation. In 1990, China's net exports totaled 21.1 million tons of crude oil and 1.1 million tons of petroleum products, accounting for over 15 percent of crude oil production. Oil-fired generation accounts for only 9 percent of power supply. Agriculture, the public sector, and demands for industrial feedstock all compete with the transportation sector for distillate fuels. Even following some required statistical adjustment, the transport sector is estimated to account for only 35-40 percent of oil use.3/

1.7 The share of natural gas use is very low—only about 2 percent of total and commercial energy consumption. In addition to the 20 million TCE of natural gas, however, about 16 million TCE of manufactured gas was consumed in 1990, produced primarily from coal. The bulk of gas consumption is in industry, where it is used both as a fuel and as a chemical feedstock. Urban household gas consumption amounted to just 4.1 million TCE, or 4.6 percent of total urban household energy use.

1.8 Primary power generation accounted for 4 percent of total and 5 percent of commercial energy consumption. Electricity generation from all sources accounts for a relatively small share of final energy consumption—about 17.4 percent of the total.4/ As with other low-income countries, a key reason is the relatively low use of electricity in the residential sector. Electricity accounts for just 3-4 percent of residential energy consumption in China and India, but it accounts for one half to two thirds in developed countries (see Annex 1, Table 3). In addition, however, the share of electricity in the total energy use in Chinese industry is low—about 25 percent, compared with 35-50 percent in other countries with major industrial sectors.5/

2/ For more details, see the Joint ESMAP/Chinese Rural Energy Study Team, *China: Training and Technical Assistance in Integrated Rural Energy Development* (1993, forthcoming).

3/ Due to the nature of the statistical reporting system, petroleum consumption by own-account transport vehicles is listed under the sector where the vehicles are owned (industry, agriculture, etc.), rather than in the transportation sector. The mission made rough adjustments to the energy balances accordingly (see Annex 1, Table 1).

4/ Electricity accounted for 22.7 percent of total final commercial energy consumption in 1990, which also is relatively low.

5/ The energy accounting of electricity used in these calculations, and others in this report, varies from standard international practice. See Footnote 1 in this chapter.

Sectoral Consumption Patterns in International Perspective

1.9 The residential sector typically dominates total energy consumption in low-income developing countries, with all other sectors accounting for fairly small shares. As development proceeds, the share of residential energy use falls, while the share of the industrial sector rises sharply. As economies reach a mature stage, the share of industry in total energy use tends to fall off, with increases in the shares of transportation (especially road transport) and the service sector (see Annex 1, Table 4).

1.10 China does not fit the normal pattern. Although China's low Gross Domestic Product (GDP) per capita classifies it as a low-income country, industry accounts for about 50 percent of total final energy consumption.6/ This compares with 28 percent in India, and less than 10 percent in most other low-income countries. The role of industry in Chinese energy use is more akin to that in Hungary and South Korea, where the share of industry in total energy use is 41 percent and 45 percent respectively. Of the developed countries surveyed, only the Japanese industrial sector holds a share of energy use as large as China's.

1.11 The share of the residential sector of final energy use in China—37.5 percent—is low compared to other low-income countries. Residential energy consumption accounts for an estimated 57 percent of the total in India, and over 80 percent in the majority of other low-income developing countries. The absolute level of residential energy use in China is not low, however—per capita residential energy consumption is of the same order of magnitude as in the other low-income countries surveyed (see Annex 1, Table 5). Rather, the low share of the residential sector in China is caused by the relatively high level of industrial energy consumption.

1.12 Agriculture accounts for just 3.3 percent of total final energy use, while the transportation sector, with its heavy concentration on relatively energy-efficient rail transport as opposed to road transport, accounts for only 5.8 percent. Energy use in the remaining, other sectors totals 3.7 percent. These shares are all typical of low-income countries.

1.13 The sectoral use patterns in China for electricity show a similar, but yet more marked, pattern compared to total energy. The industrial sector accounts for a very high 78 percent of final electricity use. This is then followed by agriculture (8 percent), residences (7 percent), and others (7 percent) (see Annex 1, Table 8).

Energy Growth Trends in the 1980s

1.14 Total primary energy consumption in China grew by 47 percent, or an average of about 4.0 percent per year, between 1980 and 1990. Of this, primary commercial (nonbiomass) energy use grew from 616 million TCE to 962 million TCE (4.6 percent per annum), while estimated biomass energy consumption grew slower, from 229 million TCE to 284 million TCE (2.2 percent per annum).

1.15 GDP more than doubled over the same period, growing at an average rat of 8.9 percent per year in real terms. The elasticities of growth in energy consumption relative to

---

6/ Excluding biomass fuels, industry accounts for 65 percent of final commercial energy consumption.

growth in GDP, therefore, were quite low. The elasticity of total primary energy consumption growth was just 0.45. The elasticity of primary commercial energy consumption was about 0.52.

1.16 China's low energy/GDP growth elasticity during 1981-90 represented a sharp break from the trend of previous years, before the opening of the economy (see Table 1.2). The factors causing this are discussed in detail in Chapter 2. China's elasticity also compares very favorably with most other developing countries, as also shown in Table 1.2.

Table 1.2: INTERNATIONAL COMPARISONS OF ENERGY/GDP GROWTH ELASTICITIES, 1966-90

	Elasticity of primary commercial energy consumption and GDP growth	
	1966-80	1981-90
China	1.4	0.5
India	1.6	1.1
Brazil	1.1	1.8
Hungary	0.7	1.1
Korea, Rep.	1.2	0.8
Low-income developing countries /a	1.7	0.9
Middle-income developing countries	1.0	1.4

/a Includes China.

Source: China: SSB data, 1982 Country Economic Memorandum; others: 1992 World Development Report (WDR).

1.17 Table 1.3 shows growth in final commercial energy consumption by sector between 1980 and 1990. Growth in commercial energy use within the major sectors was remarkably uniform. The annual average growth rates for use in transportation, industry and residential sectors were within 5.0-5.2 percent. If biomass fuels are included, however, the growth in residential energy use is only 3.1 percent per annum.

1.18 Final electricity consumption grew faster than consumption of the other major fuels. Electricity use grew by an average of about 7.6 percent per annum between 1980 and 1990. The elasticity of growth in final electricity consumption relative to GDP was just 0.85 over the period—an unusually low rate for a developing country.7/ Growth in electricity was more marked in the latter part of the decade than earlier, however. Final electricity consumption

7/ Particularly in the case of electricity in China, however, consumption is not the same as demand—major electricity shortages existed throughout the decade, but especially during the middle and late 1980s.

Table 1.3: COMMERCIAL ENERGY CONSUMPTION GROWTH BY SECTOR, 1980-90

	1980	1985	1990	Average annual percentage increase, 1981-90(%)
Final Commercial Energy Consumption (million TCE) /a				
Agriculture	30.5	36.2	42.8	3.4
Transport/Post	43.1	56.2	71.5	5.2
Industry	366.3	456.8	598.2	5.0
Residential	95.8	133.2	158.0	5.1/b
Other	31.4	42.9	55.7	5.9
Total	567.1	725.3	926.2	5.0/b
Final Electricity Consumption (TWH) /a				
Agriculture	27.0	31.7	42.7	4.7
Industry	203.5	271.5	401.0	7.0
Residential	10.5	22.3	48.1	16.4
Other	16.0	29.4	44.9	10.9
Total	257.0	354.9	536.7	7.6

/a Final energy excludes losses in conversion and distribution.
/b Including biomass fuels, energy consumption in the residential sector grew by 3.1 percent per annum, and total final energy consumption grew by 4.3 percent per annum.

Source: Annex 2, Tables 1 and 2.

grew by 8.6 percent per annum between 1985 and 1990 (with an elasticity with respect to GDP growth of 1.1), compared to 6.7 percent per annum between 1980 and 1985 (with an elasticity of 0.7).

1.19 Growth in electricity use within the major sectors was not uniform (see Table 1.3). Electricity use in industry grew by 7.0 percent per annum over the period, but use in agriculture grew by only 4.7 percent per annum. Growth in electricity use in the residential and other sectors was sharp, albeit from low 1980 base levels.

B. CHINA'S ENERGY INTENSITY IN INTERNATIONAL PERSPECTIVE

1.20 As shown in Table 1.4, primary energy consumption per unit of GDP is still high in China, compared to most of the other countries surveyed. If GDP is measured in constant 1980 US dollars, the energy intensity of China's economy is about the same as that of India, and substantially lower than most other low-income countries, as represented in Table 1.4 by Tanzania. However, China's energy intensity is roughly 2 to 5 times that of the middle-income developing countries and developed countries surveyed. If biomass fuels are excluded, China's primary commercial energy consumption per unit GDP is significantly higher than the other low-income countries surveyed, and from 40 percent to over three times higher than that of the middle income and developed countries surveyed. The difference in commercial energy intensity between China and the other countries has narrowed somewhat during the 1980s, however.

Table 1.4: INTERNATIONAL COMPARISONS OF PRIMARY ENERGY CONSUMPTION RELATIVE TO GDP, 1980-88
(Kilograms of oil equivalent/1980 $)

	Commercial Energy		Total Energy /a
	1980	1988	1988
Developi..g Countries			
China	1.44	1.01	1.31
Tanzania (1989)	n.a.	0.22	2.04
India (1980, 1987)	0.74	0.76	1.37
Brazil	0.43	0.41	0.59
Korea, Rep.	0.74	0.59	0.61
Developed Countries			
Canada	0.97	0.76	0.76
France	0.32	0.28	0.28
Germany	0.32	0.29	0.29
Japan	0.35	0.28	0.28
United Kingdom	0.40	0.32	0.32
United States	0.73	0.57	0.57

/a Includes biomass fuels in the developing countries.

Sources: 1989 China Energy Statistics Yearbook (Chinese), 1992 China CEM, 1982 and 1990 WDR, IEA/OECD, World Energy Statistics and Balances (1985-88)

1.21 By itself, simple comparison of how China's energy intensity with respect to GDP ranks with that of other countries in a given year is not very meaningful. Such comparisons should not be used as a measure of the relative performance of different countries in promoting energy efficiency, nor should they be used to quantify the energy conservation potential of different countries. One problem area concerns the comparability of the GDP statistics. For example, China's relative position changes dramatically depending upon the year used for the US dollar calculations, due to changes in the exchange rate of the Chinese *yuan* (see paras. 1.34-1.35). More fundamentally, however, the relative ranking of the energy intensities of different developing countries is heavily influenced by issues of macroeconomic and energy consumption structure that often have little to do with "good" or "bad" performance in promoting energy efficiency.

Factors Underlying China's High Energy Intensity

1.22 China's relatively high energy intensity with respect to GDP is due to a variety of natural, macroeconomic and technical factors. The most important ones are outlined below. Chapter 2 then discusses how these factors have influenced, and will continue to influence, changes in China's energy intensity over time. Policy tools which can influence many of these factors, such as pricing policy, are discussed in Chapters 2 and 4.

1.23 **High Residential Sector Energy Use Per Unit GDP.** As shown in Table 1.5, residential sector energy use per unit GDP in China and the other low-income countries is higher than in the middle-income developing countries, and much higher than in developed countries.8/ Consisting primarily of fuel for cooking and heating, residential sector energy use per unit GDP is high in the low-income countries mainly because their GDP per capita is low (by definition). While more developed countries have higher rates of household energy use per capita than the low-income countries, the differences are not of the same order of magnitude as the differences in GDP per capita. Basic needs for cooking and heating must be met in all countries, and most of the differences in residential energy use per capita are due to greater use of electric appliances in the wealthier countries.

1.24 This factor accounts for almost one half of the difference in energy intensity per unit GDP between China and Japan. Whereas residential energy use per capita in China is about one half that in Japan (Annex 1, Table 5), residential energy use per unit GDP in China is 10 times as high as in Japan (Table 1.5).

1.25 **China's High Share of Industrial Output in GDP.** Unlike other low-income countries, China's industrial sector accounted for about 46 percent of GDP in 1988. This compares with an industrial sector share of 30 percent in India, and shares closer to 10-25 percent in most other low-income countries. The share of industry in China is also slightly higher than in most of the middle-income and developed countries surveyed, where the share of industry in GDP averages around 40 percent (see Annex 1, Table 9).

1.26 Although the factors discussed below are also important, the high share of industry in GDP is a major factor contributing to the high industrial energy use per unit GDP in China shown in Table 1.5. In all countries, the energy intensity of output in industry is much higher than in the other sectors. For example, energy consumption per unit net output value in Chinese industry is over ten times as high as unit energy use in agriculture (see Annex 1, Table 10).

8/ The role of the residential sector in energy intensity trends is sometimes overlooked in analyses which exclude biomass fuels. Particularly in dealing with low-income developing countries, however, failure to include biomass fuels invites serious distortions and misinterpretation. In the case of China, where households also are a major consumer of commercial (nonbiomass) fuels, the proper comparative context of emerging trends of residential sector use of all fuels is lost unless biomass is included in the comparative analysis.

Table 1.5: INTERNATIONAL COMPARISONS OF TOTAL FINAL ENERGY CONSUMPTION PER UNIT GDP, 1988 /a
(Grams of oil equivalent per 1980 $)

	Residential	Industry/ Construction	Other	Total
Developing Countries				
China	470	624	160	1,254
Tanzania (1989)	1,583	159	159	1,901
India (1986)	683	332	183	1,198
Brazil	150	208	159	517
Korea, Rep.	177	263	145	585
Developed Countries				
Canada	150	293	284	726
France	51	87	121	259
Germany	68	107	111	285
Japan	46	143	100	288
UK	86	95	125	306
US	124	170	260	554

/a Includes biomass fuels. Final energy excludes losses in energy conversion and distribution. Figures may not add due to rounding.

Sources: 1989 China Energy Statistics Yearbook (Chinese), 1992 China CEM, 1982 and 1990 World Development Reports, IEA/OECD World Energy Balances.

1.27 **The Structure of Industrial Output Value.** The energy intensity of China's industrial sector is several times higher than that of most other countries (Annex 1, Table 10). One key reason is that the industrial product mix is weighted towards relatively low-value goods which are relatively energy-intensive to produce for the output value gained.

1.28 The real problem does *not* stem from any major abnormalities in the share of "heavy" versus "light" industry, or in the relative shares of the major industrial subsectors in total industrial output. The shares in gross industrial output value of the three most energy-intensive subsectors—metallurgy, chemicals and building materials—are not particularly out-of-line with patterns exhibited in developing or developed countries with major industrial sectors (see Annex 1, Table 11).

1.29 Rather, the problem stems primarily from the structure of output *within* the major industrial subsectors in China. The key issues involved include: (a) less diversity and specialization in the product mix of industry, compared to that in the more mature industrial sectors of developed countries, and, hence, less "depth" in sources of value-added, (b) greater dominance of basic, intermediate industrial goods (e.g., ordinary carbon steel or cement), compared with most other countries, and (c) the low quality of most industrial products, which greatly reduces the *value* side of the energy intensity calculation. (See Chapter 2 for more details.)

1.30 **Fuel Mix.** The dominance of solid fuels in China's fuel mix (para. 1.3) leads to energy efficiency penalties, especially for household use and for the supply of process heat and steam in industry. For example, the efficiency of the small coal stoves used by most urban households for cooking is generally 20-30 percent, compared to efficiencies of some 40 percent for kerosene cooking or efficiencies of 50-60 percent for use of LPG or natural gas. In industry, the dominance of coal as the primary fuel for boilers, furnaces and kilns yields efficiency penalties of up to 20 percent, compared with liquid fuel and especially natural gas.

1.31 **Inefficient Technology and Poor Energy Management.** Out-of-date, energy-inefficient technology continues to prevail throughout much of the Chinese economy. Although there has been improvement, energy management practices also generally remain well behind international levels. Continuing lack of proper incentives is a major cause. The nation's system of administrative measures has created incentives to reduce particularly conspicuous waste of energy, and increased competition and market-driven energy prices, where applicable, have improved incentives for energy saving in many of the smaller enterprises. Yet, inadequate enterprise accountability and competition, and low in-plan energy prices, have meant that incentives for efficient use of energy have continued to be inadequate for much of the industrial sector throughout the 1980s, with the result that energy consumption levels continue to be well above international rates. (See Chapter 4 for more details.)

1.32 Energy use in the production of major energy-intensive products is some 30-100 percent higher in China than in the developed countries. Some of the factors include continued prevalence of small-scale plants, use of out-of-date process technology, and tendencies to avoid increases in initial investment costs to employ energy-saving technology. (See Chapter 3 for more details.)

Some Statistical Issues in Energy Intensity Comparisons

1.33 Difficulties in making comparisons of energy use per unit of output value can arise from statistical distortions on either the energy consumption or the output value side of the calculation. In the case of China, statistical problems on the output value side are particularly troublesome. As explained in a recent Bank report, estimation of GDP through the existing statistical reporting system is fraught with difficulties.9/ The two problems which most influence the analysis in this report are exchange rate issues and problems in the estimation of industrial growth rates in constant prices during the later 1980s.

1.34 **Estimates of China's GDP in US Dollar Terms.** As shown in Table 1.4, China's primary commercial energy consumption per unit of GDP measured in 1980 US dollars amounts to 1.0 kilograms of oil equivalent (kgoe) per US dollar, or 36 percent higher than that of India, and 3.7 times that of Japan. If, however, GDP is measured in 1988 US dollars, China's energy intensity amounts to 1.75 kgoe per US dollar, or 2.7 times that of India, and

9/ See The World Bank, *China: Statistical System in Transition* (1992).

over 12 times that of Japan. The kgoe per US dollar falls in the other countries, when using 1988 as opposed to 1980 US dollars (as it should), but it rises sharply in the case of China. This is because the devaluation of the Chinese *yuan* against the US dollar over the period was far sharper than any actual change in its value (purchasing power). Resulting estimates of China's GDP in current US dollars over the period are internally inconsistent.

1.35 While it is worth noting that many Western analysts currently believe that prevailing estimates of China's GDP expressed in 1988 or 1990 US dollars are too low, it is beyond this report to suggest what estimates might be most accurate. The important points here are that (a) this issue has a major bearing on how China's energy intensity ranks with that of other countries, making such comparisons yet more problematic, and (b) this issue is the primary reason for the wide, but arbitrary, variation in such calculations for China in various studies on energy intensity in developing countries.

1.36 **Distortions in Industrial Output Value Growth Data.** Most analysts believe that current official estimates of industrial growth in constant 1980 prices are somewhat overestimated. The primary source of overestimation seems to stem from some inaccurate reporting by enterprises of output in 1980 prices, especially outside of the state sector (e.g., within the township and village industries) and where new products are involved.10/ The exact extent of the overestimation is unclear. However, it is not so major as to negate the overall trend described in Chapter 2 of an increasing share in industrial output and resulting upward pressure on energy intensity.

10/ In these areas, there has been a tendency for some enterprises to report current price values instead of 1980 price values. For a detailed description of problems in the constant-price industrial output data for the 1980s, see Thomas G. Rawski, "How Fast Has Chinese Industry Grown?" (World Bank discussion paper), March 1991.

2
PAST AND PROSPECTIVE MACROECONOMIC ENERGY INTENSITY CHANGES IN CHINA

2.1 This chapter explores how the various factors underlying China's high energy intensity described in Chapter 1 contributed to the major energy intensity reductions of the 1980s, and how these factors may or may not contribute to further energy intensity reductions during the 1990s. Because energy intensity is defined as energy consumption per unit of macroeconomic output value,1/ reductions in energy intensity are caused by both structural changes in the economy and technical improvements in energy efficiency. The primary focus in this chapter is on macroeconomic structural issues. Combined, structural factors were the main cause of the total energy intensity reduction over the last decade. Although the relative roles of different structural factors may change, structural effects should continue to be important during the 1990s. Issues relating to technical/physical improvements in energy efficiency are explored in Chapter 3 (savings potential and investment priorities) and Chapter 4 (policy).

2.2 Decreases (or increases) in energy intensity are commonly measured as percentage changes over time. In addition, Chinese analysts also use a convenient macro-level measure of "energy savings" (*jieneng liang*), which is the quantity of energy saved (not consumed) due to a change in energy intensity per unit output value between given years. In this chapter, macro-level energy savings are calculated relative to national income in constant 1980 *yuan*.2/ These measures include savings due to both structural and direct, technical factors; indeed the relative energy savings due to these different types of factors can be readily compared. In addition, quantities of such "energy savings" can be compared with quantities of actual energy supply, which is especially convenient in preparation of supply and demand projections.

1/ National income in 1980 constant yuan is the unit of measure used in this chapter, unless otherwise noted. Trends in energy use per unit national income closely track those of energy use per unit GDP, although these two measures of net economic output are slightly different.

2/ Within China, different analysts calculate energy savings relative to different measures of macroeconomic output, including gross industrial and agricultural output value, and gross or net industrial output value, in addition to national income. There are also two calculation methods—*huanbi* ("chain" comparison) and *dingbi* ("fixed" comparison). "Chain" comparison uses the previous year as a base year and energy savings calculated for a given year are relative to the previous year. Energy savings over several years are the sum of the annual savings. "Fixed" comparison specifies one base year, and savings for any given year or sum of years are calculated relative to that one year. Unless otherwise stated, "chain" comparison is used throughout this report.

2.3 Some energy conservation specialists may consider energy savings through "indirect" effects, such as structural change, to be phony, and not "real" energy savings. The relevant issue to consider is the overall objective of energy savings or efficiency improvements. If the aim is to use a minimum of energy for a maximum of social benefit, or standard of living, then indirect energy savings should be considered to be just as "real" as direct, technical energy savings. A sustained structural effect can contribute to the broader goal of raising living standards with less energy just as much as energy savings from specific energy conservation investments.

2.4 The discussion in this chapter relies upon some fairly detailed analysis previously conducted by Chinese analysts and calculations conducted by the mission. The intention is to provide a relatively simple overview of what amounts to a series of very complex phenomena. A much more substantial research effort will be required (and should be undertaken within China), to define the roles of the specific factors influencing energy intensity change, especially during the Seventh FYP and in alternative scenarios of the future.

A. OVERVIEW OF ENERGY INTENSITY CHANGES IN THE 1980S

Total Energy Intensity Changes

2.5 Commercial energy use per unit of real national income fell during 1981-90 by a total of 32 percent, or an average annual rate of 3.8 percent (see Table 2.1).3/ The energy intensity of total energy use, including biomass fuels, fell by about 35 percent, or an average of 4.4 percent per annum. (Data limitations, however, only allow detailed analysis of commercial fuels below.)

2.6 Annual commercial energy savings, relative to real national income, totaled 304 million TCE over 1981-90. This compares with an increase in domestically available energy supply of 346 million TCE.

2.7 Energy savings rates were higher during the Sixth FYP (1981-85) than during the Seventh FYP (1986-90). Energy intensity declined by about 4.8 percent per annum during the Sixth FYP, but the rate of decline slowed to 2.8 percent per annum during the Seventh FYP. Energy savings totaled 172 million TCE during the Sixth FYP and 132 million TCE during the Seventh. Energy savings levels achieved each year were fairly uniform across the 1980s, with the exception of 1989, which was a year of slow economic growth and readjustment. The fall-off in energy savings in that year appears to have been largely due to a compensation of macroeconomic imbalances created during the previous period of rapid growth, and the normal pressures against improvements in energy efficiency that tend to accompany economic slowdown.

Summary of Factors Influencing Energy Intensity Changes

2.8 Table 2.2 shows the mission's estimates of the relative roles of the main factors underlying the decline in China's energy intensity during the 1980s.

3/ Commercial energy use per unit real GDP fell by about 34 percent over the same period.

Table 2.1: Changes in Commercial Energy Intensity Relative to National Income /a, 1981-90

Sixth Five-Year Plan	1981	1982	1983	1984	1985	1981-85 (cumulative)
Change in primary energy consumption per 1980 yuan of national income (%)	-5.4	-4.0	-4.0	-4.9	-5.6	-23.9
Energy savings (million TCE) /b	35.2	26.5	27.5	36.9	45.5	171.6
Seventh Five-Year Plan	**1986**	**1987**	**1988**	**1989**	**1990**	**1986-90 (cumulative)**
Change in primary energy consumption per 1980 yuan of national income (%)	-1.9	-3.4	-3.8	-0.3	-3.7	-14.1
Energy Savings (million TCE) /b	17.0	30.4	37.4	9.7	37.8	132.3

/a Changes are very similar to, but slightly different from, changes in commercial energy intensity relative to GDP. Figures may not add due to rounding.
/b See para. 2.2 for a definition.

Source: Mission calculations based on SSB data.

2.9 For the Sixth FYP, a major research study of the Energy Research Institute of the State Planning Commission shows that only about 30 percent of the energy savings during 1981-85 was due to technical and managerial improvements resulting in "direct" energy savings (e.g., lower energy use in the production of individual products). About 70 percent of the savings was due to structural changes. Some 20 percent was due to net increases in imports of energy-intensive industrial products. One half was due to other structural changes.4/

2.10 In-depth research on energy intensity trends during the later part of the 1980s has yet to be completed. Research also will be yet more complicated than before, due to data problems. From the mission's analysis of the evidence on hand, however, trends diverge from those in the early 1980s in several key respects.

2.11 The percentage share of "direct," technical energy savings in total energy savings during the Seventh FYP increased, probably reaching some 40-65 percent. Given that both the percentage decline in total energy intensity and the absolute level of total energy savings was substantially less than during the Sixth FYP, however, this does not imply that greater success was achieved in technical energy conservation work. On the contrary, the rates of decline in energy use per physical unit of output for most commodities slowed significantly during the late

4/ See Wang Bangcheng and Xin Dingguo, ed., *A Collection of Selected Papers on Energy Conservation in China During the Sixth Five-Year Plan* (Energy Press, 1989) (in Chinese).

Table 2.2: ESTIMATED SOURCES OF COMMERCIAL ENERGY SAVINGS RELATIVE TO REAL NATIONAL INCOME, 1981-90

	Sixth Five-Year Plan	Seventh Five-Year Plan
	- (estimated percentage of total savings) --	
Structural Savings		
Residential sector effect /a	10	29
Energy industry losses effect /b	8	(2)
Sectoral structural change	(7)	(65)
Changes in trade of energy-intensive products	20	(20)-(30)
Changes in industrial product mix /c	39	93-128
Subtotal	70	35-60
Technical Savings	30	40-65
Total Savings	100	100

Note: Figures in parentheses are negative.

/a See paras. 2.16-2.18.
/b See para. 2.19.
/c These savings are over and above changes due to trade patterns in energy-intensive products.

Source: Mission estimates based on SSB data and Wang and Xin (op. cit.).

1980s, as the potential for easy, low or no-cost energy conservation remedies narrowed.

2.12 Combined, structural factors contributed some 35-60 percent of energy savings during the Seventh FYP. However, this sum hides the fact that key structural factors worked against each other, to a large degree canceling each other out.5/ The share of industrial output in real national income rose sharply, creating a strong pressure towards *greater* energy intensity. The resulting negative savings were equivalent to about 65 percent of the total energy savings actually achieved during the period. In addition, trade effects reversed, compared to those of the Sixth FYP. During 1981-85, an increase in net imports of energy-intensive products and

5/ The existence and importance of these counterbalancing structural effects is undeniable, given the magnitudes involved. Problems associated with the existing constant-price industrial output value growth indices during the later 1980s, however, make precise calculations difficult, and hence figures should be interpreted broadly (see Chapter 1, para. 1.36). It should be noted that any overestimation in the growth of industrial output value in the official statistics would result in a decrease in *both* the negative sectoral structural change effect and the estimated positive effect of changes in the industrial product mix.

modest changes in the relative contributions of different major industrial sectors both added to the overall role of structural change in the decline in energy intensity. During the 1986-90, however, net imports of energy-intensive commodities declined sharply, creating a reversed, negative energy savings.

2.13 These two, large sources of negative savings during the Seventh FYP obscure the critical role of changes in the industrial product mix in influencing energy intensity. Energy savings through changes in the mix of commodities produced by Chinese industry accelerated during the later part of the 1980s. Indeed, this factor alone probably produced energy savings more than twice as large as the total savings achieved through all technical improvements.

2.14 Details on the interplay of these structural factors are provided in the pages below.

B. THE IMPACT OF CHANGES IN SECTORAL DEMAND STRUCTURE IN THE 1980S

2.15 Although the total energy savings calculations are the same as in Table 2.2, Table 2.3 breaks down the sources of energy savings over the 1980s in a different way—by major economic sector. The calculations are relative to total national income (rather than the output of individual sectors). Therefore, the energy savings figures for given sectors include savings (or negative savings) arising from both (a) changes in that sector's share in total national income, and (b) changes in that sector's individual energy intensity. These calculations provide a convenient framework for review of the three factors influencing energy intensity change discussed above which have to do with changes in the structure of sectoral energy demand: (a) the "residential sector" effect, (b) the "energy industry losses" effect, and (c) changes in the structure of output between the major production sectors.

The Role of the Residential Sector

2.16 As explained in Chapter 1 (para. 1.9), the intensity of residential energy use relative to economic output is high in low-income countries such as China, and residential energy use will tend to grow substantially less than economic output over the long term in these countries. This trend can be observed in China during the 1980s, and can be expected to continue to provide substantial macro-level energy savings in the future. This will be true even if household electricity use continues to grow very rapidly.

2.17 Commercial energy use by households grew at a robust 5.1 percent per annum between 1980 and 1990. Much of this growth was due to substitution of coal for biomass fuels in rural areas—including biomass fuels, total household energy use grew by only 3.1 percent per annum. Household electricity use more than quadrupled. Because it accounts for only a small share of total household energy use, however, this increase in electricity use accounted for less than a quarter of the total increase in household commercial energy use.

2.18 Despite the strong growth in residential sector commercial energy use over the period, real national income grew faster, rising by over 9 percent per annum. The resulting energy savings, relative to national income, were about 45 million TCE, or 17 percent of total

Table 2.3: TOTAL COMMERCIAL ENERGY SAVINGS BY ECONOMIC SECTOR, 1981-90 /a

	Sixth FYP (1981-85)		Seventh FYP (1986-90)	
	MTCE	% of Subtotal	MTCE	% of Subtotal
Material Production	129.3	80.0	69.3	72.4
Agriculture	10.5	6.5	7.9	8.3
Construction	1.1	0.7	5.0	5.2
Transport/Post	10.3	6.4	7.7	8.0
Commerce	0.8	0.5	-0.6	-0.1
Industry	106.6	65.9	49.3	51.5
Nonmaterial production	3.5	2.2	0.1	0.0
Household use	16.6	10.3	28.0	29.3
Energy Industry Losses	12.3	7.6	-1.7	-1.8
Subtotal	161.7	100.0	95.7	100.0
Statistical discrepancy /b	9.9	-	36.5	-
Total Final Consumption	171.6		132.3	

/a The "chain" calculation method is used. Figures may not add due to rounding.
/b These statistical discrepancies are from the "statistical discrepancy" rows in the official SSB energy balances, and thus cannot be resolved. Although small in the 1980-88 balances, the discrepancies are particularly large for 1989 and 1990.

Source: Mission estimates based on SSB data (see Annex 2, Tables 3 and 4).

savings between 1980 and 1990. The "residential sector effect" was most important during the Seventh FYP, contributing about 29 percent of savings during that period (see Table 2.3).

The Role of Energy Industry Losses

2.19 Slower growth in energy industry losses, relative to real national income, accounted for about 4 percent of total energy savings between 1980 and 1990 (see Table 2.3). Energy industry losses or own use as defined here primarily include electricity use in power plants and electricity losses in transmission and some distribution; petroleum losses and use in oil field operations and refining; and coal losses and use in mining and coal processing. While there were some notable improvements in technical efficiencies, especially in petroleum refining, the bulk of the macro-level savings was due to the fact that energy production grew slower than national income. Energy industry losses are largely proportional to energy production. Energy production grew by an average of 5 percent per annum between 1980 and 1990. Energy industry losses grew by 5.5 percent per annum.

Structural Change Between Production Sectors

2.20 As shown in Table 2.3, energy savings arising from the industrial sector during the Seventh FYP were less than one half of what they were during the Sixth. As the energy intensity of industrial production continued to decline at robust rates (see Table 2.6), the key reason was the substantial increase in the share of industry in real national income. Already high for a low-income country in 1980, the share of China's industry in real national income rose even further during the 1980s, especially during the later part of the decade. As explained in Chapter 1 (para. 1.26), higher shares of industry in economic output lead to higher energy intensity, as industry is far more energy intensive than agriculture or services.

2.21 Measured in constant 1980 prices, the official Chinese data shows an increase in the share of industry in total national income from 48.9 percent in 1980 to 56.3 percent in 1990.6/ During the first few years of the 1980s, the share of industry fell, but it began to increase substantially at the end of the Sixth FYP. In 1985, the share was 49.5 percent, or just slightly higher than in 1980 (see Table 2.4). During the Seventh FYP, the share rose steadily.

Table 2.4: Sectoral Shares of Real National Income, 1980-90

	Percentage of National Income in Constant 1980 Prices /a		
	1980	1985	1990
Agriculture	36.0	33.7	28.7
Construction	5.0	5.4	5.0
Transport/post	3.4	3.7	3.9
Commerce	6.7	7.8	6.1
Industry	48.9	49.5	56.3

/a Figures may not add due to rounding.

Source: SSB, *Statistical Yearbook of China, 1991.*

2.22 As Table 2.5 and Figures 2.1 and 2.2 show, this had a profound effect on macro-level energy intensities. Table 2.5 shows the net increases or decreases in energy savings that resulted from changes in the distribution of national income. During 1981 and 1982, when the share of industry fell slightly, this provided small energy savings. After that, however, changes in the structure of national income stemming from the boom in industrial growth caused

6/ Analysis of the distribution of national income in current prices "hides" the fact that the share of industry rose substantially; in current prices, the share of industry actually fell from 48.9 percent in 1980 to 45.8 percent in 1990. However, industrial prices were under relatively strict control, and increased less than prices in the nonindustrial sectors. If the influence of these differences in relative price changes is omitted, the share of industry increased.

Table 2.5: ENERGY SAVINGS DUE TO CHANGE IN THE STRUCTURE OF MAJOR PRODUCTION SECTORS, 1981-90
(million TCE of savings relative to national income) /a

	Sixth FYP (1981-85)	Seventh FYP (1986-90)
Agriculture	2.8	6.6
Construction	(0.8)	1.0
Transport/post	(4.4)	(2.5)
Commerce	(0.8)	(2.7)
Industry	(8.8)	(70.0)
Total	(12.0)	(62.2)

/a Figures in parentheses are negative.

Source: Annex 2, Table 5.

major losses in energy savings. These negative savings were 12 million TCE during the Sixth FYP, rising to about 62 million TCE during the Seventh FYP.

Reductions in Sectoral Energy Intensities

2.23 Table 2.6 illustrates the role of the other factor influencing energy savings levels—the decline in energy intensity within each individual sector. With the exception of commerce, the energy intensity of all of the major economic sectors fell during both of the FYP periods. In the industrial sector, energy intensities fell sharply during both periods. Although the energy intensity of total material production fell by only 2.0 percent per annum during 1986-90, due to the canceling effect of the rising share of industry, the available data shows industrial energy intensities fell by as much as 4.2 percent per annum during that period.

C. INDUSTRIAL OUTPUT STRUCTURE AND INDUSTRIAL ENERGY INTENSITY

2.24 Aside from the impact of changes in the structure of output between the major economic sectors, the other key category of structural change impacting energy intensity is change in the structure of industrial (net) output value. Industrial structural change is driven by change in the mix of products produced by industry. As production of some products grows faster than others, industrial energy intensities change, because some products are far more energy intensive per unit of output value than others.

2.25 Quantification of energy savings due to changes in the industrial product mix is very difficult, as so many products are involved. It is difficult to separate the impact of

Figure 2.1: Annual Change of the Share of Industry in National Income
(National Income in constant 1980 prices)

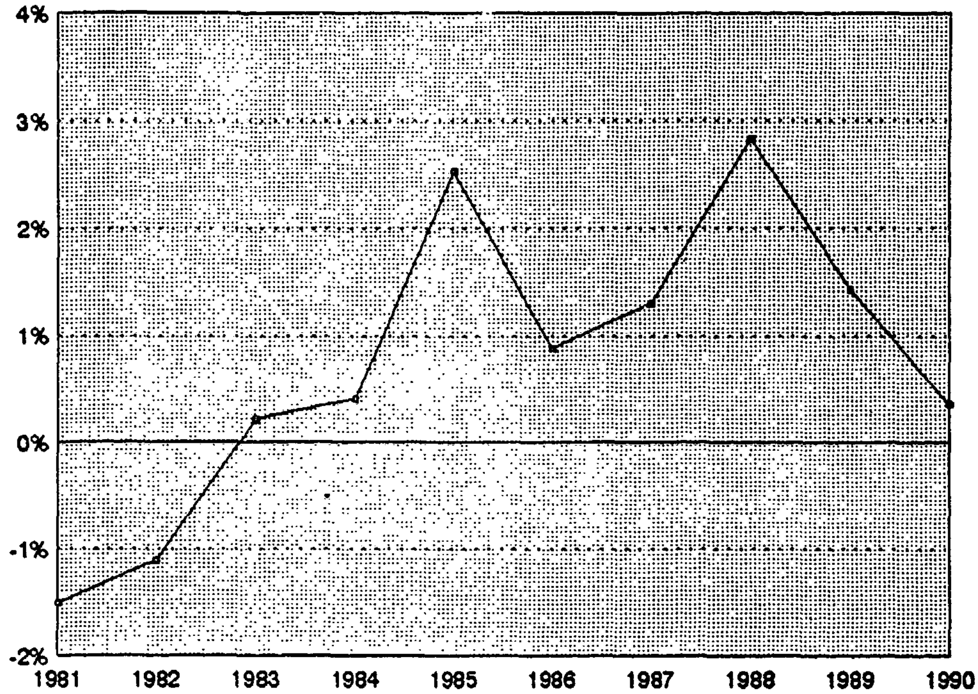


Figure 2.2: Energy Savings Due to Changes in Sectoral Structure
(In million TCE)

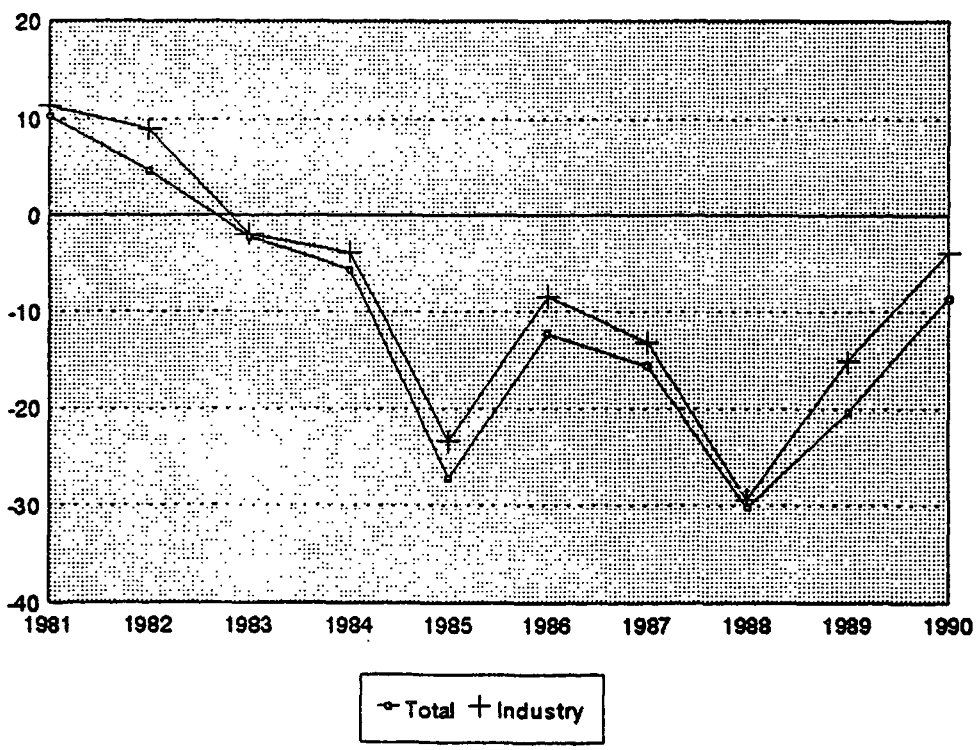


Table 2.6: REDUCTIONS IN SECTORAL ENERGY INTENSITIES, 1981-90

	Energy Intensity (kgCE per Y 1,000 of Contribution to National Income)			Annual Average Percentage Change (%)	
	1980	1985	1990	1981-85	1986-90
Agriculture	230	181	176	-4.7	-0.1
Construction	448	348	237	-4.9	-7.4
Commerce	196	157	209	-4.3	5.9
Industry	2,030	1,556	1,253	-5.2	-4.2
Total Material Production /a	1,228	956	865	-4.9	-2.0

/a Transportation is included in the total, but not listed separately, due to adjustments in the energy balance which distort the figures for this sector.

Source: See Annex 1, Table 6.

structural factors from the impact of technical improvements in the energy use per physical unit of output of each commodity. Typically, the impact of industrial structural change on energy intensity is measured through analysis of changes in the relative contribution of major industrial subsectors (e.g., changes in the contribution of heavy and light industry, or of the metallurgical sector, chemical sector, etc.). This captures a portion of the impact of industrial structural change, but of course excludes structural change effects within the major subsectors. Moreover, in the case of China during the 1980s, the available evidence indicates that the structural change effects which have had the most important role in industrial energy intensity decline are just these *intra*sectoral structural effects. At times, focus upon the *inter*sectoral structural effects alone has caused analysts to understate the overall importance of industrial structural change on energy intensity, and the importance of the fundamental factors underlying such change, such as greater product diversification, improvements in product quality, and trade patterns. At times, policy responses also seem to have focused on efforts to promote intersectoral structural change to reduce energy intensity, rather than the more appropriate focus on underlying factors.7/

Impacts of Change in the Structure of Output Between Industrial Subsectors

2.26 During the early 1980s, analysts put considerable emphasis on the impact on energy intensity caused by changes in the relative shares of heavy and light industry in industrial output. Aside from substantial energy savings achieved at the outset of the 1980s, captured with an initial decline in the share of heavy industry, however, the shares of light and heavy industry,

7/ This is particularly true at local government levels, where planners sometimes have considered development of heavy industry to be "bad" and light industry "good," due to their wide differences in energy intensity.

in constant price terms, have been fairly stable. These measures are too aggregate to meaningfully describe the impact of structural change.

2.27 Analysis at the next level of aggregation—the industrial subsectors of metallurgy, chemicals, machine building, etc.—provides somewhat more insight. During the Sixth FYP, structural changes at the subsector level were substantial. One analysis estimates that intersectoral structural change accounted for about 28 percent of the decline in industrial energy intensity during 1981-85, while reductions in the energy intensity within each industrial subsector (due to both structural change within subsectors and declines in energy use due to technical/managerial improvements) accounted for the remaining 72 percent.8/

2.28 Appropriate data to calculate the impact of changes in the structure of output between subsectors during the Seventh FYP was not available to the mission. The impact of structural changes measured at the subsector level, however, do not appear to have been substantial, and may indeed have been virtually nil or even negative.

Changes in the Energy Intensity Within Industrial Subsectors

2.29 Table 2.7 shows growth in energy consumption by industrial subsector between 1985 and 1990.9/ Energy consumption growth in the three most energy-intensive subsectors—metallurgy, chemicals and building materials—was fairly strong. Energy consumption growth in the machine building sector, which was a major source of growth in industrial output value, was strikingly low at just 1.7 percent per annum.

2.30 Table 2.7 also shows declines in the energy intensity relative to real gross output value of the individual subsectors based on the State Statistical Bureau's (SSB) separate series of unit energy consumption statistics. These figures cannot be strictly compared with the net output value figures used elsewhere, and the percentage declines can be expected to be somewhat overstated (para. 1.36). However, the declines are so sharp, relative to what has been common in other countries, that the conclusion that structural change within the industrial subsectors was a key factor in overall energy intensity reduction is inescapable. This is particularly true given the fact that trade effects worked to *increase* industrial energy intensity over the period. The percentage improvements in technical efficiencies for major industrial products (Chapter 3, paras. 3.4-3.5) do not yield close to the magnitude of positive energy savings required to both overcome the counterdirectional trade effect and yield the dramatic intensity reductions shown in the SSB data.

2.31 In industry as a whole, energy use per unit real *gross* output value was reported to decline by 5.5 percent per annum during 1986-90. This compares with a decline per unit of real *net* output value of 4.2 percent per annum during 1986-90 and 5.2 percent per annum during 1981-85 (Table 2.6). The reported energy intensity of the machine building industry fell

8/ See Liu Feng, "Energy Efficiency and Economic Development: Energy Consumption and Economic Growth in China Since 1978" (Lawrence Berkeley Laboratories, July 30, 1989).

9/ The previously published energy consumption series for industrial subsectors during the early 1980s is not comparable with the series for the later 1980s, as classifications are different. Authorities also state that the quality of the energy use data for the series for 1985 and beyond is substantially better than for the past series.

Table 2.7: ENERGY USE AND INTENSITY BY INDUSTRIAL SUBSECTOR, 1985-90

	Total Final Energy Use /a			Energy Use Per Unit Real Gross Output Value /b		
	1985	1990	Average Annual percent change, 1986-90	1985	1990	Average annual percent change, 1986-90
	(million TCE)		(%)	(TCE/Mln 1980 Yuan)		(%)
Metallurgy	89.5	123.4	6.6	1,740/d	1,540/d	-2.4/d
Chemicals	78.4	108.2	6.7	1,433	1,026	-6.5
Building materials	78.8	95.4	3.9	1,627	1,074	-8.0
Machine building	39.3	42.7	1.7	200	118	-10.0
Textiles	23.2	29.5	4.9	196	164	-3.5
Food, bev., tobacco	23.1	31.7	6.5	241	204	-3.3
Energy industries /c	42.1	60.6	7.6	n.a.	n.a.	n.a.
Other	61.8	84.0	6.3	n.a.	n.a.	n.a.
Total	436.3	575.4	5.7	570	430	-5.5

/a Figures may not add due to rounding.
/b Figures are from a specific energy intensity data series, reported from lower levels. Authorities report that this series yields more accurate data than manipulation of aggregate energy consumption and GVIO data.
/c Excluding energy losses and energy industry own use.
/d Ferrous metals only.

Sources: Mission estimates based on SSB data.

extremely sharply, declining by over 40 percent (10.0 percent per annum). However, this is consistent with the energy use data for the subsector, and the energy intensity of this subsector has tended to decline substantially in other countries as well.10/ The other major subsector where energy intensity declines due to structural changes (as well as technical improvements) are normally expected—chemicals—showed a strong 6.5 percent average decrease per year. The building materials subsector also reported an above-average decline in energy intensity. In this case, problems associated with the constant price output value statistics may have played a substantial role, as TVEs are especially prominent in this subsector.

The Effect of Trade in Energy-Intensive Industrial Products

2.32 China in the 1980s provides a good case study in how international trade in industrial products can have a substantial impact on national energy intensity. For energy-intensive products, which consume many orders-of-magnitude more energy per unit output value than the national average, increases in imports or decreases in exports cause reductions in energy intensity. Effectively, imports of "embodied energy" are increased, or exports of embodied

10/ See the World Bank, *China: Long-term Issues and Options, Annex C: The Energy Sector* (1985).

energy are decreased. In considering the impact of trade on energy intensity, however, direct trade in energy is not considered, as it is not included under total energy consumption.11/

2.33 Chinese analysts estimate that increases in net imports of energy-intensive products accounted for about 20 percent of the total national reduction in energy intensity during the Sixth FYP.12/ Between 1980 and 1985, the mission estimates that net imports of energy embodied in energy-intensive industrial products rose by almost 41 million TCE. The key factor was the major increase in steel imports during 1983-85, although increases in imports of chemical fertilizer and nonferrous metals were also important (see Table 2.8).

2.34 During the Seventh FYP, this pattern was rather dramatically reversed. Net imports of embodied energy fell by about 36 million TCE between 1985 and 1990. Again, the key factor was steel, as steel imports fell off sharply during the Seventh FYP. By 1990, steel imports were only one tenth of the 1985 level. Whereas energy demand pressure from the metallurgical industry was relieved somewhat during the early 1980s by imports to meet a portion of demand, energy demand pressure increased during the later 1980s, as the metallurgical industry was called upon to both meet incremental demand and provide some substitution for imports. By 1990, net imports of embodied energy were only some 5 million TCE higher than the 1980 level.

Nontrade Structural Change Effects Within Industrial Subsectors

2.35 Clearly, there were other structural changes within the industrial subsectors that had a major influence on energy intensity, in addition to the changes caused by patterns of trade in energy-intensive products. During the Sixth FYP, these other nontrade-related changes in the structure of output with industrial subsectors appear to have accounted for around 15-25 percent of total energy savings in industry. Then, during the Seventh FYP, the role of nontrade-related changes in the industrial product mix clearly expanded, both in percentage terms and in terms of total energy savings. While this cannot be accurately quantified at present, it is clear from the facts that (a) energy intensities in the individual subsectors declined sharply, (b) if the energy intensity declines are adjusted for trade effects the declines are even sharper, and (c) percentage improvements in physical energy efficiencies, due to technical and managerial changes, are far too small to account for these declines, and generally slowed in the later 1980s, relative to the gains of the Sixth FYP, at least for the major commodities surveyed.

2.36 **The Role of Basic Intermediate Goods.** One important aspect of change in the industrial product mix has been a slower growth relative to overall industrial output of production and consumption of many of the key basic, energy-intensive intermediate industrial goods, such as pig iron, steel, nitrogen fertilizer, and aluminum (see Annex 2, Figure 1). This was particularly true during the Seventh FYP. Between 1985 and 1990, growth in real net industrial output is reported at over 10 percent per annum. However, production of steel, which

11/ Energy used to produce or process traded energy commodities, however, is included in calculating the impact of trade of energy embodied in industrial products.

12/ See para. 2.9. This calculation correctly includes consideration of the changes in output value as well as the energy use changes that would have occurred if there had been no changes in the relative role of industrial trade over the period.

Table 2.8: ESTIMATED NET IMPORTS OF EMBODIED ENERGY IN ENERGY-INTENSIVE INDUSTRIAL PRODUCTS
(million TCE)

	Net imports						Change in net imports
	1980	1981	1982	1983	1984	1985	1981-85 /a
Coal & coke	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.0
Petroleum & products	-5.0	-5.1	-5.2	-4.0	-6.8	-8.5	-3.5
Paper & pulp	1.6	1.7	0.1	1.1	1.2	1.7	0.1
Rolled steel	11.8	7.1	7.0	12.3	28.0	45.1	33.3
Copper & aluminum	2.3	0.1	2.7	6.7	4.7	8.1	5.7
Polyethylene	0.1	0.2	0.8	0.8	1.3	1.3	1.2
Chemical fertilizer	8.4	9.2	10.0	13.0	14.9	12.2	3.8
Total	18.8	13.7	15.8	29.6	43.0	59.5	40.7

	Net imports					Change in net imports
	1986	1987	1988	1989	1990	1986-90 /a
Coal & coke	-0.4	-0.6	-0.8	-0.8	-0.9	-0.6
Petroleum & products	-8.1	-7.7	-7.5	-7.1	-7.2	1.4
Paper & pulp	1.5	1.8	1.6	1.3	1.4	-0.3
Rolled steel	40.2	26.0	17.6	17.7	4.4	-40.7
Copper & aluminum	4.1	2.2	0.8	2.3	0.7	-7.4
Polyethylene	1.2	1.2	1.7	0.9	0.6	-0.8
Chemical fertilizer	8.1	17.1	22.9	21.4	24.8	12.6
Total	46.6	40.0	36.3	35.7	23.9	-35.6

/a Figures may not add due to rounding.

Sources: Mission estimates, based on import and export data from the *Statistical Yearbook of China*, various years (foreign trade department data for 1980, customs data for 1981-90, 1980 coal imports estimated by the mission); and unit energy consumption data from Wang and Xin (for 1980) and other Chinese sources (for 1981-90).

accounted for 17 percent of total industrial energy consumption in the late 1980s, grew by only 7.2 percent per annum between 1985 and 1990, even with the substantial import substitution noted earlier. Over the same period, cement output grew by 7.5 percent per annum, and nitrogen fertilizer output grew by 5.1 percent per annum.13/

13/ Growth in real output value from the production of these commodities, however, would be expected to be somewhat higher, due to increases in real output value per ton stemming from quality changes.

2.37 In the case of the chemical industry, energy intensity declined by 5.9 percent per annum during the Sixth FYP. Indirect, structural changes are estimated to have accounted for 46 percent of the decline, while technical/managerial improvements are estimated to have accounted for 54 percent. In this case, however, most of the structural changes stemmed from the relatively slow growth of nitrogen fertilizer output. Output of nitrogen fertilizer grew by only 2.7 percent per annum during 1981-85, and this particular industry accounted for over 60 percent of the energy use and almost 30 percent of the total output value of the chemical subsector at the beginning of the decade.14/

2.38 The key issue concerning the role of basic intermediate goods is the efficiency of their use in other industries or sectors. This includes, for example, improving the efficiency of steel use in machine building, the efficiency of use of building materials in construction, or the efficiency of use of basic chemicals in downstream chemical industries. From a macro perspective, improving the efficiency of use of energy embodied in other goods can be as important as improving direct energy efficiency.

2.39 The machine building industry provides a good illustration. This subsector consumes about 5 percent of the nation's primary energy. Including all of the energy embodied in intermediate inputs, however, this subsector is estimated to consume about *one third* of the national total.15/ Although direct energy consequences may be fairly small, there are dramatic differences in how well a factory producing heavy, low-quality machinery with cast-iron footings ultimately translates embodied energy into value-added, compared with a factory producing modern, high-quality precision equipment.

2.40 **Increasing Value-Added Per Unit Energy.** Much of the analysis of energy intensities in China puts insufficient emphasis on the value side of the fraction. Increases in the value of output are just as important as decreases in energy input. Key factors which are becoming increasingly important in China are the development of new products and product diversification, and improvements in the quality of output.

2.41 Increasing product diversification and the specialization and sophistication of products have provided key sources of growth in value-added in the developed countries over the last two decades, with minimal growth in physical raw material inputs. This has been especially the case in the chemical, machine building and many of the light industrial subsectors, but similar changes also have begun to take place in the building materials industry, with the development of new, lighter products to substitute for bricks and cement. One aspect of the trend is, in effect, the substitution of "technology inputs" for raw material inputs. This type of substitution tends to accompany increases in product specialization and sophistication, especially in the chemical and machine building subsectors. Another aspect is the increase in unit value that tends to accompany product diversification and specialization stemming from increasing efforts by producers to more precisely meet the needs of consumers. Product value, represented by the price that consumers are willing to pay, tends to increase where consumers can select, from a series of choices, the product that best caters to their specific needs.

14/ See Wang and Xin.

15/ Zhou Fengqi, "The Progress of Energy Conservation Work in China," *Energy of China* (No. 1, 1989) (in Chinese).

2.42 With the opening of China's economy and economic reform, these trends also are becoming increasingly important in China. One relatively simple example of the importance of changes in the product mix arising from increased product diversification can be seen in the case of light industry. During the Sixth FYP, the output of light industry grew by 10.9 percent per annum, while the sector's energy consumption grew by just 5.1 percent per annum. This resulted in a decline in energy intensity of over 5 percent per annum. Detailed calculations show that 77 percent of this decline was due to indirect, structural changes, while just 23 percent was due to improvements in energy efficiency in physical terms, due to technical or management improvements. Chinese analysts state that the chief causes of the high structural energy savings were the development and production of a large variety of new products, and major increases in the production of relatively nonenergy-intensive, high value consumer products such as household electrical appliances, clothing, beer and jewelry.16/

2.43 A related issue, which has tended to be overlooked in China, is the importance of product quality. Improvements in product quality is one of the most important areas for industrial energy savings in the future. The value of a high quality item, expressed in the real prices that consumers are willing to pay, is often much higher than the value of a similar item of low quality, but the direct and embodied energy required for production typically is about the same. In addition, a higher quality item may last longer or be more productive, resulting in additional, indirect energy savings. The often dramatic differences in energy use per unit of output value between different factories producing the same item, but with very different quality characteristics, may seem to some to be phony since they are caused by the difference in output prices. Where the prices are market driven, however, they are indicative of the different values to society. Such differences in value, stemming from differences in the quality of output, are one of the major reasons why Chinese industries tend to show higher energy intensities, relative to output value, compared to international counterparts.

2.44 One example of the importance of quality differences that is generally well recognized in the Chinese energy conservation community concerns cement—projects to upgrade the strength and consistency of cement production, with basically the same energy inputs, are often classified as "energy conservation projects." The same recognition of energy savings benefits can be applied elsewhere, in connections with improvements in the quality of, say, crude steel output, finished steel products, nitrogen fertilizer (e.g., production of urea as opposed to ammonia bicarbonate), and heavy machinery, not to mention a wide range of light industrial products.

16/ The output value of household electrical appliances increased fivefold, and the resulting structural savings from this alone accounted for some 13 percent of the total energy savings in light industry. See Wang and Xin.

D. Policy Conclusions and the Outlook for the Future

Targets for the 1990s

2.45 Energy production targets for 1995 and 2000 are about 1200 million TCE and about 1,400 million TCE, respectively.17/ Assuming that net exports decline, this would allow consumption to increase by 3.6 percent per year between 1990 and 2000. To achieve a conservative average annual growth rate in national income of 6 percent, the corresponding elasticity of growth in energy use with respect to national income growth would need to be 0.6. Energy intensity would need to decline by about 2.3 percent per annum. Energy savings requirements total about 135 million TCE during the Eighth FYP (1991-95) and about 145 million TCE during the Ninth (1996-2000), for a total of about 280 million TCE.18/ This is just about the same as the total savings achieved during 1981-90. It compares to a targeted increase in energy supply of 420 million TCE.

2.46 These energy savings goals for the 1990s can be attained. It also should be possible to attain economic growth rates above 6 percent per year with only modest increases in energy supply above targeted levels, but this will not be easy. Achievement of dramatic gains in both technical and structural savings will be required if a serious energy supply constraint on economic growth is to be avoided. In both areas—structural savings as well as technical savings—achievement of the existing potential will depend largely upon whether or not China's government promotes the required policies.

2.47 On the technical side, there clearly is great potential for further energy savings. The remaining gap between unit energy consumption levels in China and those in the developed countries shows that the savings potential is several hundred million TCE. The savings potential, priorities for investment, and required policy reforms are discussed in Chapters 3 and 4.

2.48 The potential contribution of structural energy savings in China during the 1990s has been a topic of considerable debate in the Chinese energy community. Some analysts argue that most of the potential for structural savings has already been achieved, pointing to the decline in net structural savings that occurred during the latter part of the 1980s. As shown above, however, the net total figures hide a major counterbalancing between different structural effects. The increase in the share of industry in total real national income and the decline in net imports of energy embodied in energy-intensive products both represented major pressures towards increased energy intensity. Although technical energy efficiency improvements also played a role, the still significant net industrial energy savings of the Seventh FYP were largely the result of major structural energy savings due to changes in the industrial product mix within industrial subsectors. These structural savings were impressive enough to both counterbalance the other trends and also contribute to net positive gains. In the future, the factors creating the negative structural effects are likely to diminish, or even provide a source of some positive energy

17/ The official 1995 target includes 1260 million tons of coal, 155 million tons of oil, 20 billion cubic meters of natural gas, and 152 TWh of primary electricity. The year 2000 target includes 1,400 million tons of coal, up to 200 million tons of oil, 30 billion cubic meters of natural gas, and 270 TWh of primary electricity.

18/ The "chain" comparison method is used.

savings. With continued progress in economic reform, however, the downward pressure on industrial energy intensity caused by changes in the product mix should continue to be strong.

2.49 Largely for this reason, the mission concludes that great potential remains for structural effects which can produce further major declines in energy intensity over the 1990s.

The Role of Policy in Structural Energy Savings

2.50 Some structural effects which are expected to continue to produce energy savings have little to do with government policy, and are "natural." These include:

(a) **The "Residential Sector Effect."** Over the long term, continued substantial energy savings can be counted on from slower growth in residential energy use relative to growth in national income. Actual medium-term commercial energy savings rates will be influenced by rates of substitution for biomass fuels and the rate of growth in national income. Further improvements in technical efficiencies in the sector also can add to savings. Household electricity consumption can be expected to continue to grow rapidly, but the macro-level impact on energy intensities should not be major, as the percentage share of household electricity consumption will remain small.

(b) **Slower Growth in Energy Industry Losses.** Growth in energy production at slower rates than national income growth, due to energy savings from other factors, will produce some additional energy savings through slower growth in energy industry losses, relative to national income. Growth rates in electricity supply above national income growth rates, however, may counterbalance the effect of slower growth in fuel supply.

2.51 Other structural effects are tied to underlying trends of economic development, the progression of which is influenced by macroeconomic policies. The impact of these structural effects on energy intensity during the 1990s is linked to the rate of progress in overall economic reform. Effects in this category include:

(a) **The Sectoral Distribution of Economic Output.** Best measured in terms of the shares of GDP, the key issue here for the 1990s is the relative roles of the industrial and services sectors. If real industrial net output grows at the same rate as GDP, and faster growth in the service sector makes up for the expected slower growth in agriculture, the major counterbalancing effect on energy savings of the increasing share of industry over the Seventh FYP would be eliminated. Changes in the relative contributions of industry and services to future growth can be expected to track the rate of increase in market-orientation in the economy.

(b) **Trade in Energy-Intensive Products.** The sharp decline in net imports of energy embodied in industrial products of the Seventh FYP, which produced substantial negative energy savings, is not expected to continue during the 1990s. Steel imports have already fallen far from the peak levels of the mid-1980s. If China's trade pattern increasingly emphasizes the country's comparative advantage, modest energy savings might actually result, from possible increases in imports of nonferrous or specialty metal products, or some chemical products for which use of petroleum or natural gas feedstocks is most cost effective internationally, such as urea.

(c) **Other Changes in the Industrial Product Mix.** Potential continues to exist for major energy savings through improvements in the efficiency of use of energy-intensive commodities, and through increases in industrial value-added, from greater product diversification and specialization, and improvements in product quality. This maturation of China's industrial sector is a long-term process. However, further policy reform supporting greater competition, cost-consciousness and profit-seeking among enterprises would provide a major boost in this direction, and a corresponding key source of energy savings over the medium term.

2.52 The future role of effects (a) and (c), in particular, are tied to progress on system reform, including the related issues of increasing the role of the market, increasing competition, and increasing enterprise autonomy. These two effects also are by far the most important structural effects in terms of the size of their influence on total energy intensity changes. The two effects are interrelated—increases in product diversification and technological sophistication tend to require expansion of service sector inputs. Progress on system reform will also be important for realization of the potential for technical energy savings, as discussed in Chapter 4.

2.53 Obviously, broad issues of system reform are outside the scope of direct concern of energy policymakers. Still, proper recognition of the continued importance of indirect structural energy savings puts proper perspective on what issues count the most in the evolution of China's energy demand trends: the shape of China's macroeconomic policies will most likely have a greater influence on energy demand trends during the 1990s than the level of achievement in technical energy efficiency improvements.

2.54 In addition, however, authorities involved in resource conservation or technical renovation investment should more strongly recognize the energy conservation value of projects which provide major indirect energy savings. Recent Chinese programs to promote savings of steel, which have been attached to the government's broader, energy conservation effort, are an example of a positive trend here. Although such projects need not be attached to the specific energy conservation investment initiatives, full recognition of the energy savings benefits could also be awarded to projects that improve product quality or otherwise increase value-added without increases in energy use.

2.55 Finally, it is worthwhile to note that the same structural effects, and determining policy requirements, that are important for reducing China's energy intensity are also central to China's environmental protection effort. Recent studies have shown that the types of macroeconomic structural change discussed here, and related broad technological shifts, have played a greater role in the developed countries in reducing pollution and environmental costs than remedial environmental protection efforts, such as retrofit, end-of-pipe pollution control investments.19/

19/ See "Economic Structure and Environmental Impact," in The World Bank, *China: Environmental Strategy Paper*, 1992.

3
STRATEGIC TECHNICAL ENERGY CONSERVATION ISSUES

3.1 This chapter provides an overview of strategic issues for China concerning "technical" or direct energy conservation efforts. In contrast with the indirect, structural factors leading to reductions in energy intensity discussed in the last chapter, the focus here is on reducing energy consumption per unit of *physical output*. This may be achieved through technological changes or through improved energy management practices.

3.2 The first section of the chapter reviews how key Chinese unit energy consumption indicators have changed over the 1980s and how they compare with those in developed countries. Following a summary of the potential for improving technical energy efficiency, the next section explores several strategic issues, especially those relating to the question of the energy efficiency of new industrial capacity. Issues discussed include the role of improvements in process technology and scale economies, spatial issues, and the need to improve the efficiency of capital goods. The next section provides a summary of priority areas for improving the efficiency of electricity use; this was an area of special focus in the mission's fieldwork. A final section includes a summary of specific issues involved in the effort to improve the efficiency of coal use.

3.3 The mission's review of technical energy conservation issues was selective. A number of important areas, especially efficiency issues surrounding household energy and petroleum product use, warrant serious review in the future. Further work also needs to be done to establish more definite energy conservation investment priorities at subsector levels, through rigorous subsector-by-subsector analysis of technical options and benefits and costs. This work will be undertaken as a key component of the new joint Chinese/Bank study supported by the Global Environment Facility (GEF), "China: Issues and Options for Greenhouse Gas Emissions Reduction."1/

A. TECHNICAL ENERGY EFFICIENCY IN CHINESE INDUSTRY

Declines in Unit Energy Consumption in the 1980s

3.4 Table 3.1 shows the declines in energy consumption per physical unit of output that occurred during 1980-90 for major energy-intensive industrial products. Excluding thermal power, the commodities surveyed together account for about 35 percent of total industrial energy

---

1/ This study began in April 1992 and is expected to require two years for completion.

Table 3.1: CHANGES IN UNIT ENERGY CONSUMPTION FOR SELECTED INDUSTRIAL PRODUCTS IN THE 1980S

Commodity	Unit Consumption 1980 (TCE/t)	Unit Consumption 1990 (TCE/t)	Total % Change 1980-90	Average Annual Present Change 1981-90
Crude Steel				
Comparable consumption in key plants	1.20	1.00	-17	-1.8
Comprehen. consumption in all plants	2.04	1.62	-21	-2.3
Thermal Power				
Plants above 6 MW (gross kgCE/kWh)	0.413	0.392	-5	-0.5
Plate Glass				
Key plants (KgCE/standard case)	30.85	28.59	-7	-0.8
Cement Clinker (1980-89)				
Large & medium plants	0.207	0.188	-9	-1.1
Small plants /a	0.177	0.167	-6	-0.6
Ammonia (1980-88)				
Large plants	1.53	1.36	-11	-1.5
Medium plants	2.50	2.21	-12	-1.5
Small plants	3.00	2.46	-18	-2.5
AN plants	2.57	2.17	-16	-2.1

/a Shaft kilns only.

Source: Mission estimates based on a variety of Chinese data sources.

consumption. While the savings shown are impressive in many cases, they have been disappointing in some.

3.5 Of individual industrial products, the 21 percent decline in unit energy consumption per ton of crude steel had the greatest overall impact on total energy demand during 1980-90. Major savings also were achieved in the ammonia industry, especially within the small-scale plant sector. Declines in unit energy consumption in the cement, glass and thermal power production were more modest. Although consistent data are not readily available, there are indications of significant improvements in a broad range of other industries. In the brick and tile industry, which is dominated by township and village enterprises, a recent Ministry of Agriculture report suggests that unit energy consumption fell by one third between 1985 and

1990. There also have been significant improvements in industrial boiler efficiencies in many enterprises, particularly through programs to renovate existing units.

Sources of Success in Reducing Unit Energy Consumption

3.6 The success achieved in reducing unit energy consumption during the 1980s was largely a result of the government's policies to promote energy conservation. At the outset of the decade, energy consumption was largely unmonitored, and the concept of energy efficiency as an issue was completely alien to most enterprise managers. With the steady support of China's senior leaders, however, energy conservation became an important part of the energy and industry development agenda at both central and local government levels. Under strong government support, monitoring of energy consumption has greatly improved, and energy efficiency has become one of the standard criteria used in assessing enterprise performance and investment project proposals. Specialized energy conservation offices, service centers, and investment financing facilities to promote the government's program have been developed at central and local levels. Large numbers of technical staff have been trained, enterprise auditing capabilities have developed, and countless technical manuals and reports have been disseminated for use by factory engineers. (See Chapter 4, paras. 4.3-4.20 and Annex 3.)

3.7 This effort has brought results. Particularly noteworthy has been the success in promoting "housekeeping measures," which include a wide variety of improvements in energy management practices and relatively small investments with generally short payback periods. Some examples are improvements in insulation, reductions in steam or hot water losses from leaks or faulty valves, and improvements in operating practices for energy-using equipment. As managers were prodded to pay attention to energy use patterns, often for the first time, major improvements were made in these areas over the 1980s. Such measures clearly were a key source of the technical savings achieved over the decade, especially in the early years.

3.8 Success also has been achieved in the promotion and implementation of a variety of projects focussing on the renovation of key, energy-intensive aspects of existing industrial production facilities. Such projects typically include investments in waste heat utilization or cogeneration, to improve regulation of production processes, and to replace or rebuild energy-inefficient equipment. As many of the nation's mainstream industries completed the most obvious housekeeping improvements, emphasis on energy conservation retroffiting and renovation projects increased during the later 1980s. A series of attractive "generic" investment projects have been identified in the key subsectors, and demonstrated through pilot schemes. Although much work remains to be done, China's institutional network for promoting energy conservation also has proven its capability to foster the implementation of such projects on a broad scale (see paras. 3.22-3.23).

3.9 With the increasing opening of the economy over the decade, imports of foreign equipment and application of imported technology also has had an impact on energy efficiency levels, both directly and indirectly. Probably the most dramatic example is in the case of automobiles. In industry, the impact of foreign technology has been greatest in the large-scale, relatively modern sector. Two examples where a direct relationship between unit energy consumption rates and utilization of foreign technology can be seen include the thermal power and integrated steel industry, where imports of selected high efficiency equipment has been followed by the development of domestic capabilities to produce some items of such equipment. In many other cases, however, the utilization of foreign technology has been surprisingly limited, especially in the small and medium-sized heavy industries which account for such a large portion of China's energy consumption. Two examples include the coal-based ammonia industry and the small and medium-sized cement industry.

Unit Energy Consumption Levels in International Perspective

3.10 Despite the progress made over the 1980s, energy consumption per physical unit of output of major energy-intensive products is still some 30-100 percent higher in China than in developed countries (see Table 3.2). Efficiency penalties associated with the dominance of coal as the primary industrial fuel is a contributing factor. The most important technical factor,

Table 3.2: INTERNATIONAL COMPARISONS OF ENERGY USE FOR THE PRODUCTION OF SELECTED INDUSTRIAL COMMODITIES
(kilograms of coal equivalent/ton) /a

	China	Developed Countries
Crude Steel, 1990 /b		
Key plants	1.00	
Total	1.10/c	0.65-0.85
Ammonia, 1988		
Natural gas in key plants	1.35	1.00-1.15
Coal and Coke /d	2.40	1.60-1.70
Total	2.17	1.00-1.15
Cement, 1989 /e		
Medium and large plants	0.20	
Small plants	0.19	
Total	0.19	0.12-0.13/f
Thermal Power (Kgce/kWh), 1990 /g		
Units above 6 MW	0.39	0.33-0.34/h

/a Electricity is converted at thermal replacement values.
/b "Comparable consumption," based on Chinese definitions.
/c Rough estimate.
/d Chinese data also includes plants with fuel oil feedstock.
/e Integrated consumption per ton of cement, including electricity. The quality of cement produced in small plants is lower than that produced in the larger plants.
/f Figures are exclusively for dry process plants.
/g Gross heat rates (excluding the own use of generating plants).
/h Typically system averages for steam plants.

Source: Mission estimates based on review of variety of Chinese and international data.

however, is the type of technology that has been employed. At issue is not only the relatively backward technical levels of older plants still in production, but also the choice of technology for the large amount of new capacity added during the 1980s.

3.11 Historically, China has tended to opt for industrial technology which is relatively low in capital intensity, but relatively high in raw material intensities, rather than the reverse. Decentralized industrial development also has been a major thrust, due to transportation constraints and desires for local self-sufficiency. These trends are captured together in China's major small-scale industrial sector. Small-scale plants account for large shares of China's total output of key, energy-intensive commodities, including over one half of ammonia production, over 80 percent of cement output, and over 90 percent of brick and tile production. The proliferation of small-scale plants in other sectors, such as machine building and the light industries, also has led to large numbers of small-sized key energy-consuming equipment, such as boilers or furnaces. Typically, the small-scale plants are relatively low in capital intensity, require shorter construction periods, and are close to the markets they serve. Small-scale heavy industrial plant output continued to grow rapidly during the 1980s, especially in the effort to meet the high demand of the industrial boom years of 1985-88. In these industries, however, most small plants produce lower quality output and require higher energy inputs.2/

3.12 Comparative energy efficiency levels in several key industries are briefly discussed below. Additional efficiency comparisons are made in the major sections on electricity and coal use in the later parts of this chapter.

3.13 **Iron and Steel.** China's iron and steel industry consumed about 98 million TCE in 1990, or 10.2 percent of total primary commercial energy use. Differing from most other countries, a substantial amount of energy in China is still used in the production of pig iron for direct consumption. Excluding this consumption, and other energy use which is not directly associated with steel production, energy use per ton of steel mill products in China is still about 35 percent higher than in the United States.3/ Part of the reason for this is that small and medium-sized plants outside of the core, "key plant" sector still account for some 30 percent of output, and with average energy consumption rates about 60-65 percent above the US average. With the major improvement over the 1980s, comparable energy consumption rates in China's key steel plants are now about 20 percent above those in the United States (but still over 50 percent higher than those in Japan). Higher energy use rates in China's key plants stem largely from the low level of scrap use (and hence, greater iron production requirements), the low quality of iron ore, and, in some cases, continued use of out-of-date and small blast furnaces. Compared with the United States, however, energy use in shaping and finishing is

---

2/ These small-scale heavy industrial plants should not be confused, as a sector, with TVEs. Although there are some township and village cement and ammonia plants, most of the small-scale plants in these sectors are state-owned. Certainly, some parts of the TVE sector are well-known for inefficient energy use--one example is the "backyard" coke production industry in Shanxi Province. On the whole, however, energy intensities in the TVE sector have declined sharply in recent years, as the sector has shifted away from the energy-intensive industries. The share of building materials (the dominant energy-intensive subsector among TVEs) in total output value fell from almost 50 percent in 1985 to 34 percent in 1989.

3/ For details on the energy intensity of this Chinese industry and how it compares with that in the United States, see Marc Ross and Liu Feng, "The Energy Efficiency of the Steel Industry of China" (Lawrence Berkeley Laboratories, 1990).

relatively low, due to less sophistication in the mix of finished product, and this may rise in the future.

3.14 **Ammonia.** Energy use in the production of ammonia, the key component of nitrogen fertilizer, was about 43 million TCE in 1988 (4.6 percent of primary commercial energy use). Average energy consumption per ton in the industry as a whole was about double the rate achieved in most modern plants internationally. The primary reason is the heavy concentration of production in medium and small-scale plants using anthracite or coke as feedstock. Large natural gas-based plants accounted for 21 percent of output in 1988). They consumed about 9.5 gcal/ton produced, compared to 7.0-8.0 gcal/ton in advanced international plants. Medium-sized plants, using mostly coal, but also petroleum-based feedstocks as well, accounted for 22 percent of output and consumed 15-16 gcal/ton. Small-scale plants based on coal accounted for 57 percent of production,4/ and averaged a little over 17 gcal/ton. Despite the energy inefficiency of the small plants, their output grew by over 40 percent over the 1980s. The dominant fertilizer produced in the small plants, and many of the medium-sized ones--ammonia bicarbonate--is also inferior to the urea which dominates nitrogen fertilizer output internationally.

3.15 **Cement.** The cement industry consumed some 40 million TCE in 1989, just slightly less than the ammonia industry. Most of the industry's capacity is new, as cement output almost tripled over the decade, following the rapid pace of construction. However, 92 percent of incremental cement production between 1980 and 1988 was from small plants.

3.16 As a whole, the industry consumed roughly 50 percent more energy per ton of cement than modern dry-process rotary kilns abroad, and produced cement of substantially lower quality. Medium and large-scale plants accounted for 18 percent of production in 1989. Consumption rates per ton of clinker in the medium and large-scale sector are 75-85 percent higher than in advanced international plants because of out-of-date technology; only 33 percent of these plants rely on dry process production, while 14 percent rely on semi-dry technology and 53 percent still use the wet process. The small-scale plants, which account for 82 percent of total cement output, are primarily vertical shaft kilns. Energy use per ton of clinker is slightly less in these kilns than in China's medium and large-scale plants. Although strength requirements are different for some of the cement used in the rural areas and small towns often served by the smaller plants, the cement which they produce is generally inferior.5/ With proper management and mechanization where appropriate, energy consumption rates of 130-135 kgce/kilogram clinker could be achieved with shaft kiln technology, compared to the 1989 average of 167 kgce/kilogram.

3.17 **Thermal Power Production.** China's thermal power plants at or above 6 MW of capacity registered an average gross heat rate of 392 grams of coal equivalent per Kwh in

---

4/ The share in 1988 was a little higher than in years before and after; in 1980 and 1990, the production share of these plants was about 55 percent.

5/ About 85 percent of cement produced in the medium-sized and large plants is grade 425-525. In 1987, 52 percent of small plant output was grade 325, while 44 percent was 425, and 4 percent was higher.

1990, or a generation efficiency of 31 percent.6/ The heat rate was brought down by about 5 percent over the 1980s, despite difficulties experienced in efforts to decommission older, small units because of chronic power shortages. The average heat rate is some 15 percent higher than typical averages for existing coal-fired plants in the industrialized countries, and over 25 percent above the rates achieved in new large-scale units abroad. Lack of scale economies is a key factor. Over one-half of China's capacity is in units under 200 MW. Only 12 percent is in units of 300 MW or more, compared to 60-80 percent in industrialized countries.7/ Additional efficiency penalties also are caused by poor or inconsistent coal quality. Recent comparisons of a number of domestically produced 200 and 300 MW turbine/generator sets with units abroad of the same size also showed that the heat rates of the Chinese units were some 10 percent higher than the foreign ones.8/

B. STRATEGIC ISSUES FOR THE 1990S

The Potential for Improving Technical Energy Efficiencies

3.18 While the mission did not conduct a comprehensive review of the potential for increasing technical energy efficiencies, broad estimates indicate that attainment of efficiency performance levels of the developed countries today would result in total energy savings of about one-third of total current consumption. This is the conclusion of several recent Chinese analyses.9/ The figures shown in Table 3.2 imply that attainment of the efficiency levels of developed countries in these key cases would, hypothetically, yield a savings of some 15-50 percent. In the case of industrial boilers, which account for about 40 percent of total industrial energy use, an increase in average efficiencies from 55-60 percent to the 75-80 percent more typical for coal-fired boilers internationally would result in savings of some 20-30 percent. In the case of electricity, efficiency performance at developed country levels in transmission, distribution and end use would provide potential savings of some 25-30 percent (see paras. 3.37-3.38).

3.19 Obviously, however, such major improvements in efficiency levels cannot occur overnight in a country with an industrial sector as large as China's; the process of technological change and capital stock turnover is a gradual one. Based on current conditions in China, it is perhaps useful to divide efforts to improve technical energy efficiencies into three categories: (a) housekeeping measures, (b) renovation or replacement of key energy-consuming equipment or other improvements in the efficiency of existing processes, and (c) changes in process technology, through major renovations, the addition of new capacity, and industrial restructuring.

6/ The gross heat rate, or consumption per kWh generated, does not include the own electricity consumption of power stations.

7/ In addition, about 10 GW of the total 83 GW of thermal capacity in the country is in units below 6 MW which are not included in the average heat rate statistics. Although these plants are usually owned by major industries and operated at low capacity utilization rates, heat rates for these units typically exceed 600 gCE/kWh.

8/ Zhou Dadi, et al., "Electric Power System Inefficiency" (Report of the Energy Research Institute of the SPC for Lawrence Berkeley Laboratories, 1990).

9/ See, for example, Lu Gengshan, "Energy Conservation as an Important Technical Path towards Increasing the Economic Results of Enterprises (in Chinese), *Energy in China*.

Housekeeping Measures, Renovations and Retrofitting

3.20 Although clearly less than before, significant potential also remains for improving efficiency through housekeeping measures. In most large enterprises and relatively advanced parts of the country, such as those visited by the mission, most of the potential for these relatively simple improvements appears already to have been tapped. For many smaller enterprises in less advanced regions, however, incentives for energy savings remain crude and uneven, and monitoring of energy use patterns remains poor. These factors lead to poor energy management.

3.21 The major thrust in energy conservation efforts currently being pursued in China is in the second category--investment projects for improving the efficiency of existing processes. Examples of such projects in industry include investments for: (a) improved utilization of waste heat and/or addition of cogeneration facilities, especially in the chemical industry, (b) boiler renovation or replacement, (c) renovation or reconstruction of industrial kilns or furnaces, (d) improved recovery and use of by-product gases in the iron and steel industry, (e) power transformer replacement, and (f) expanded process monitoring and control, in part through computer-based facilities. The potential for energy savings through such investments remains large, especially in the energy-intensive subsectors. In some cases, financial returns are lower than for most other available industrial projects, especially in cases where energy savings and reduced pollution are the only project benefits and energy prices are low. There are, however, many projects in this category which yield sound financial rates of return on a life-cycle basis. This is especially true for the renovation projects which also provide other benefits, such as increased output or improved output quality, in addition to energy savings and environmental gains.

3.22 The current approach used in China for identification and promotion of renovation projects is a good one. Based on assessment of trial applications, sometimes supported under pilot project initiatives, "generic" investment projects are selected for widespread promotion across regions within the relevant subsector. One example of a successful project type which is currently being promoted on a broad scale is the application of computerized raw material input controls in small-scale vertical cement kilns, which substantially improved the quality of clinker produced with the same, or slightly less, energy. Another example is the capturing and utilization of waste heat from chemical reaction for process heat in the small-scale ammonia industry. This generic project is termed "one coal replacing two coals" as it eliminates much of the need for steam coal for process heat in plants using coal as feedstock.

3.23 The State Economic and Trade Office (SETO) also has developed a new program for promoting replacement of outmoded equipment with more energy-efficient models, which holds promise and deserves support. The program provides loans for purchase of high-efficiency equipment to replace energy wasting units, which are paid back in three years or less from the profits gained through reduced energy costs. The program focusses on electric pumps, fans and blowers, and some coal-using equipment.

Improving Process Technology

3.24 Continued, strong efforts to promote further housekeeping measures and energy conservation projects focussing on renovation and retrofitting of existing processes are clearly essential, as some of the more detailed discussions on electricity and coal conservation in this chapter show. For the nation as a whole, however, there is a critical need to balance this thrust with more effort on modernizing the basic technology employed. The issues here are broader than just energy efficiency, involving modernization of industrial process technology both to improve the efficiency of use of all manner of inputs, and to improve the level and especially the quality of output. Unlike the renovation projects, the broad efforts required here generally fall outside of the natural scope of operations of specialized energy conservation agencies. Nevertheless, efficiency improvement through changes in process technology must be a key area of concentration in the future if China is to make inroads in closing the gap between current domestic technical efficiency levels and those abroad.

3.25 The fact is that too much of the *new* capacity added during the later 1980s is well below international efficiency standards. This is due both to continued deployment of out-of-date technology and plant scale which is too small to properly capture scale economies. As the new capacity added during the 1980s now accounts for a dominant share of the country's total, this means that a major opportunity has been lost. There also is a need for a more critical and aggressive approach to restructuring some of China's older, particularly out-of-date capacity; promotion of marginal energy conservation projects can be a waste of resources in such cases, where more major changes or plant closure may be more appropriate.

3.26 To realize the potential for energy efficiency gains, comprehensive energy conservation strategies are needed for the principal energy-intensive subsectors, strategies should explicitly include (a) transfer and/or adaptation of modern international process technology, especially for new capacity, (b) priority energy conservation initiatives to improve the efficiency of mainstream existing capacity and processes, and (c) industrial restructuring to eliminate (or transform) the most inefficient elements of existing capacity. In other words, the prospects for achieving major energy efficiency gains through broad improvements in process technology need to be considered together with the prospects for savings through more narrowly defined energy conservation renovation projects. This type of approach has been adopted in plans for some subsectors, but actual implementation often requires greater efforts, in part due to the issues raised in paras. 3.30-3.31 below. In drawing up these strategies, positive environmental impacts, stemming both from declines in energy intensity as well as from other aspects of industrial modernization, should be explicitly identified and analyzed.

3.27 An example of a subsector where such an approach needs to be implemented is the cement industry. As described previously, cement output almost tripled over the 1980s, but with little change in process technology and a reduction in unit energy consumption during 1980-88 of only some 6 percent. Energy use per ton was still 50 percent higher in 1989 than in modern kilns abroad. Small-scale shaft kilns accounted for most of the increase in production capacity, but some new wet process capacity also was added in the medium/large-scale industry. Dry process technology still accounted for only 6 percent of cement production in 1989. To realize the major potential for further energy savings in this subsector will require suitable investment funding levels for (a) construction of modern dry process plants to meet incremental demand for high quality cement, (b) conversion of wet process plants to semi-dry process, where economic, (c) renovation of mainstream small-scale shaft kilns, where economic, to increase mechanization, improve process control, and increase cement quality, and (d) restructuring of the small-scale industry to best conform with evolving demand for different quality levels of cement, and to eliminate the most inefficient plants.

3.28 Another example is the synthetic ammonia industry. Although more substantial gains were achieved in reducing unit energy consumption, there also was little change in basic production technology over the 1980s. Reliance on coal as a feedstock is a major reason for the relative energy-inefficiency of this industry. However, the prevailing techniques for making nitrogen fertilizer from anthracite or coke in medium and small plants also are very inefficient, especially considering the low quality fertilizer produced. The renovation projects to better utilize waste heat in these plants which are currently being promoted (such as the "one coal replacing two coals" projects) yield good economic returns and have an important role to play. However, there also is a need to look at more fundamental issues, including (a) the best future role of coal-based ammonia production over the medium term, (b) the best future role of the small-scale plant sector, and how this sector might be restructured to improve economic efficiency, (c) increased production of urea as opposed to ammonia bicarbonate, and (d) adaptation of more efficient and modern coal gasification technologies in the industry.

3.29 To increase gains through broader industrial modernization and upgrading of process technology, mobilization of adequate investment resources is a major challenge. More modern industrial processes generally are more capital intensive than those prevalent in China's industry today. Although returns on such investment may be handsome, due to lower operating costs (including energy cost) and, sometimes, improved output quality, technological modernization and improved realization of economies of scale both require greater up-front investment.

3.30 Looking over the middle and later 1980s, much of the reason for disappointing gains in improving energy efficiency through improvements in process technology or economies of scale appears to stem from pressures to meet strong demand quickly, with relatively small sums of up-front capital, and with the same, familiar technology. These pressures were strongly reinforced by distortions in the financial/investment allocation system which have caused biases towards small investment projects as opposed to concentrated investment projects.10/ While it was easiest to meet demand growth in many of the industrial subsectors through less capital-intensive, smaller, and more rapidly gestating projects, this now carries long-term penalties in terms of high recurring costs, such as energy costs.

3.31 Over time, a strengthening of competition, both domestically and through further development of international trade, can greatly improve the environment for industrial modernization, bringing the life-cycle cost advantages of modern technology fully to bear. Financial sector reform, however, also is urgent, to improve the prospects for mobilizing the necessary concentrated investment resources.

Spatial Issues

3.32 Chinese industrial areas typically include a wide variety of large, medium and especially small-scale factories, built at different times and operated by an array of different agencies. Individual factories typically are operated completely autonomously even when very small, with separate heat, steam, gas and/or auto generating electricity supply systems. Supply and use of complementary raw or intermediate materials also may not be integrated, even where

---

10/ One aspect of the problem is that local governments can undertake and fully control smaller investment projects, but large projects require central approval and involvement.

mutually beneficial gains are obvious, for institutional reasons.11/ From a technical point-of-view, major gains can be made in energy efficiency and environmental protection through greater integration in secondary energy supply, through development of centralized heat, steam, gas and cogeneration facilities which can serve a number of plants in the immediate vicinity. These gains are achieved through economies of scale both in secondary energy production and in pollution control. Recent worthwhile efforts in China have included some retrofitting projects to construct more centralized utility services in existing congested industrial areas. Perhaps the greatest potential for application, however, is in the development of new industrial parks. Current plans for integrated power generation, heat, steam and gas supply in the new Pudong industrial area in Shanghai are a large-scale example.

3.33 Although major efficiency gains can be achieved through integrated utility facilities, development is complicated, and requires effective planning, large up-front investment, and institutional coordination. Disadvantages for enterprises may include loss of flexibility and control over key energy inputs. Load optimization and equitable pricing or cost allocation can be complicated. For these reasons, promotion should be on a case-by-case basis, based on local conditions.

Improving the Efficiency of Capital Goods

3.34 Improving the energy efficiency of new equipment produced in China, especially of equipment used in industry, also is an issue of strategic importance. New equipment put in place today will have a major impact on efficiency levels into the next century. Two areas of particular concern are industrial boilers and electrical equipment, especially industrial electric motors and the equipment which relies on them, such as industrial fans and pumps. As discussed in greater detail in the sections below, the mainstream models being produced in China today are typically less energy-efficient than mainstream models internationally, let alone high-efficiency models abroad.

3.35 The government, including the Ministry of Machinery and Electronics Industry, has increased emphasis on improving the energy-efficiency of energy-using equipment in recent years, and made significant progress. However, these efforts urgently need to be strengthened and expanded. Progress has been made in development and initial production of a number of economically viable higher efficiency items (including electric motors). Investment and policy support is now required to put the best items into mainstream, mass production. Pricing policy for such equipment must be reviewed and revised, so that the economic attractiveness of these items can be fully brought to bear in the marketplace (see Chapter 4, paras. 4.49-4.50). Transfer of foreign technology, especially through joint-venture production, needs to be more strongly encouraged. Further research and development (including improvements in production methods) also is required. The efficiency of China's current high-efficiency motor models, for example, is still significantly behind international advanced levels. The quality of some higher efficiency items, such as compact fluorescent lamps, also needs to be improved, to best gain consumer acceptance.

11/ Examples are common in the petrochemical industry and in the metallurgy/metal-working industries.

3.36 A related issue is the need to realize opportunities to improve efficiency through improvements in electronic instrumentation and monitoring equipment. With China's electronics industry receiving greater attention and direct foreign investment in recent years, China can take advantage of new advances in electronic instrumentation to greatly improve energy consumption monitoring and equipment control. This has been a key to improving energy management in more developed countries. Some of the areas with major opportunities include computerized industrial energy management systems, more sophisticated controls for energy-intensive equipment such as boilers, and more sophisticated but inexpensive metering devices such as time-of-day power load meters.

C. IMPROVING THE EFFICIENCY OF ELECTRICITY USE

Overview of the Potential for Improvement

3.37 To deliver and convert electricity produced at the power generator to useful mechanical drive at an industrial plant, losses are incurred in the power generating plant, transmission and distribution system, and the electric motor and coupled mechanisms. In China, these losses total about 45 percent of the power generated. This is 60-80 percent higher than the loss levels which can be achieved using modern technology applied in developed countries (some 25-28 percent of generation).

3.38 As shown in Table 3.3, losses in China within the power system itself are at least 25 percent of total power generation,12/ including about 7 percent losses within power plants plus at least 18 percent in transmission and all aspects of distribution. This total compares to some 15-17 percent in modern, thermal-power-based systems in the developed countries. China's current stock of electric motors account for about two thirds of total final consumption of electricity, and one-half of total power generation. The average efficiency of motors in use is probably about 75 percent, compared to some 88 percent achieved in high-efficiency motors of comparable size commercially available in developed countries. In most of the other end-uses of electricity, such as lighting, heating, and use in electric home appliances, similar substantial gains in efficiency also could be achieved.

3.39 Table 3.3 also provides illustrative estimates of the net costs per kilowatt-hour of electricity saved through various measures to improve the efficiency of electricity use. These measures include the production and adoption of more efficient motors (and the pumps and fans which they drive), lighting equipment and home appliances, the accelerated replacement of high-loss transformers with more efficient transformers, and the addition of more capacitors to improve system power factors. Although individual cases vary, major gains in all of these areas can be achieved at life-cycle costs of less than 12-15 fen/kWh in 1991 prices. Although costs vary substantially by region and voltage level, long-run marginal costs of electricity supply were in the vicinity of 20-25 fen/kWh in most areas in 1991. This shows that the types of electricity conservation investments reviewed are highly cost effective from the nation's perspective compared with increases in supply. For different consumers, however, the financial attractiveness of these types of investments vary substantially, due to great variation in electricity prices. In 1991, most enterprises faced effective prices of over 20 fen/kWh (including prorated per kilowatt charges for allocation rights for new load) for at least some of their power supply.

12/ See Lu Gengshan, p.11

Table 3.3: ESTIMATED ECONOMICALLY VIABLE POTENTIAL FOR IMPROVING ELECTRICITY EFFICIENCY

	Estimated percentage of total power generation, 1989 (%)			Estimated cost of conserved energy of key conservation measures /a (fen/kWh)
		Losses Current (%)	Losses Potential (%)	
Generating Plant				
Thermal plant own use	7/b	8	4-6	8-12/c
Hydro plant own use	0	1	1	
Transmission & Distribution				
Total losses	18/d	16-20	10-12	5-10
Power factor correction				2-6
		Efficiency Current (%)	Efficiency Potential (%)	
End Use				
Motors	50	75	88	8-12
Lighting	7	12	16	8-10
Heating	9	25	40	n.a.
Appliances	5	/e	/e	12-15
Other	4	n.a.	n.a.	n.a.

Note: "n.a." denotes that estimates are not available.

/a The cost of conserved energy is the present value cost per kWh saved (net of any other benefits) from selected major energy conservation investments reviewed by the mission.
/b Own use in thermal power plants was about 8 percent of thermal power generation, but less than 7 percent of total power generation.
/c Considers improvements in motors, blowers and fans.
/d Current estimates range from 15 percent of total generation to over 20 percent.
/e Potential savings through improvement in the efficiency of the current stock is in the order of 25-30 percent.

Source: Mission estimates.

For enterprises which still received all of their power at low, in-plan prices of some 10-15 fen/kWh, however, many of the investments reviewed in electricity savings were not financially attractive, or only marginally so.13/

Reducing Power System Losses

3.40 **The Own Use of Electricity of Power Plants.** In 1988, Chinese power plants consumed 6.7 percent of total power generation. Thermal power plants consumed 7.9 percent, while hydro plants used 0.3 percent. In thermal power plants, electricity consumption depends on the power use levels of pilot generators, pumps blowers and other equipment, the type and quality of fuel, and the diurnal operation of the plants. In China, the own use of electricity in thermal power plants is 2-4 percent higher than in the industrialized countries. Losses could be reduced through improvements in generator efficiency, and the efficiency of the auxiliary equipment, through use of higher efficiency pumps, fans, etc.

3.41 **Transmission and Distribution Losses.** Including all aspects of the distribution system, regardless of ownership, actual transmission and distribution losses in China's power system total 16-20 percent.14/ In urban areas, which account for about two thirds of total power consumption, recent surveys show losses on the order of 15 percent. Including county-managed state-owned industry, rural areas account for about one third of national power consumption. Losses in this part of the system vary dramatically and have not been systematically monitored. Ministry of Energy officials report that losses average 33 percent.

3.42 In the municipalities, some of the problems adding to losses are old and out-of-date equipment, including transformers and the equipment supporting wires, inadequate control of reactive power losses, and transmission line cross sections which cannot sufficiently support the load now carried. An estimated 40-60 percent of the transformers are out-of-date high-loss models. Power factor problems stem both from insufficient capacitance and difficulties in proper load regulation, given deficiencies in equipment and the number of properly skilled operators.

3.43 In rural areas, at least two thirds of the estimated losses occur at voltage levels below 10 kV. The main causes of the extraordinarily high losses include15/:

(a) Out-of-date transformers. About 80 percent of the almost 2 million transformers in rural networks are high-loss, SJ4-type models.

13/ Such enterprises also tend to be large consumers. For discussions on the need for energy price reforms to better support energy conservation, see Chapter 4.

14/ The often-cited published data series on transmission and distribution losses indicates losses of a little over 8 percent during the later 1980s. These figures generally include losses within those parts of the power system which are under direct management of state power companies. In many cases, this excludes much of the low-voltage system. Losses in the state companies are usually recorded only up to the substations which mark the point of sale. The substantial losses thereafter are the responsibility of the purchasing enterprises or collectives.

15/ Additional analysis of rural power system losses, based in part on several case studies, is provided in ESMAP, "China: Planning and Management of Decentralized Power Companies" (1992).

(b) Low power factor. Actual power factors today are estimated to be about 0.7, as opposed to the mandated 0.8.

(c) Irrational network configuration. Substation capacity, line cross-sections and line lengths typically do not conform with current loads.

3.44 To reduce losses will require network renovations, to improve configurations and increase line cross sections; transformer replacements and other substation overhauls; and further addition of capacitance to improve system power factors. Investments in the transmission and distribution will need to increase. Whereas transmission and distribution investment accounted for 22.5 percent of power sector capital construction investment in 1985, this share declined to 17.7 percent in 1989. This declining trend must be reversed to avoid further increases in losses, let alone allow for significant loss reductions.

3.45 **Transformers.** China's power transformer industry is well established. Until 1986, production focused on "high-loss" SJ4 oil-cooled units. Transformers of this type rated at 1,000 kVA/10 kV have total losses of about 17 kW (1.7 percent).16/ Although new installation of these units is now banned, these transformers still dominate the network in many areas. Currently, the main units produced are "low-loss" S7 models, which have rated losses of 13.4 kW. Newer, yet more efficient units also are now available, including S9 and S15 models, with losses of 12.0 kW and 11.63 kW, respectively. As of October 1991, ex-factory prices for the S9 and S15 units reported to the mission were about 20 percent higher than for the S7 models.

3.46 The mission's analysis shows that accelerated replacement of existing high-loss units is economically attractive from a national perspective, but financial viability for power companies depends upon electricity price levels. At the prices given, higher cost of purchasing the more efficient S9 or S15 units also is justified by the electricity savings provided, as long as electricity prices are greater or equal to 13 fen or 10 fen/kWh, respectively. As with many investments in improved efficiency, the challenge is to acquire the up-front funds to cover the higher initial costs.

3.47 **Adding Capacitance.** In high-voltage bulk transmission and in urban networks, typical power factors are not exceedingly poor, but there is room for improvement. In bulk transmission, power factors are typically about 0.9. In the city of Wuhan, the system power factor is reported at 0.85, which appears typical. In rural areas, however, average power factors of 0.7 present a major problem.

3.48 Reducing reactive power losses by adding capacitors is one of the most cost-effective measures currently available for improving the efficiency of the power system. Increased capacitance is both economically and financially attractive in bulk transmission, urban networks, and especially in the countryside. Power company officials need to recognize the importance of improved monitoring and identification of opportunities in this area. Local government bureaus also need to be more active in clarification of the roles of industry and the power utilities in making improvements, and should make sure that proper incentives are in place.

16/ Includes both full-load and no-load losses.

Increasing the Efficiency of Electricity End-use

3.49 Efforts to improve the efficiency of electricity use need to focus both on the industries which manufacture electrical equipment and on electricity applications in industry and other sectors. Electricity transformation is limited to four major types--illumination, drive power, heating and electrolytic processes. Because of this, the types of industries producing electrical equipment are limited and can be easily targeted through various programs to improve efficiency. On the other hand, electricity applications number in the thousands. Improvements in their efficiency requires an extensive, project-by-project effort. Electricity efficiency improvements in individual industries involve not only efforts to use the most efficient equipment, but also improved production management and improvements in industrial processes.17/ In the section below, the primary focus is improving the efficiency of electrical equipment; review of improvements in efficiency in various key applications will need to be pursued in future subsector-by-subsector analyses.

Electric Lighting

3.50 About 7 percent of electricity generation (42 TWh in 1989) is used for lighting. The principal area for efficiency improvement is through substitution of fluorescent lamps for incandescent lamps, which typically use 4-5 times as much electricity to deliver the same amount of light. Application of fluorescent tube lamps, which produce a lower-quality light compared with incandescent lamps, appears close to market saturation in China today. Major gains, however, can be achieved through use of compact fluorescent lamps (CFLs), which can substitute for incandescent lamps both in terms of light quality and in terms of socket applications. Compared with incandescent lamps, however the costs of CFLs are much higher--about ten times higher, given the current Chinese market prices observed by the mission. Although the lifetimes of properly manufactured CFLs also are orders-of-magnitude higher than that of incandescent lamps, their use is generally only financially attractive in applications where they are used several hours per day.

3.51 A variety of CFLs are produced and sold in China today Many models, however, are of inferior quality. Actual lamp lifetimes are sometimes well below rated levels, resulting in consumer dissatisfaction, and undermining dissemination efforts. Improvements in quality will require improvements in production technology.

Electric Motors and Associated Equipment

3.52 Electric motors and associated equipment account for the bulk of electricity consumed in most countries. In China, about 50 percent of total electricity generation, or about two thirds of total final electricity use, is used to drive electric motors. This includes free-standing motors coupled to other machinery, as well as motors integrated into pumps, fans and other machines used in the various economic sectors.

17/ The most obvious case where process changes are critical for electricity efficiency improvement is in the coal-based synthetic ammonia industry, where current plants typically have no cogeneration facilities and consume about 100 times the electricity per ton of output as modern, natural-gas based plants.

3.53 China's stock of electric motors currently in use is especially inefficient by world standards, as it is dominated by inefficient J-series motors which were the mainstay of the Chinese motor production industry until only recently. Some modest improvements can be made through retrofitting. A unique retrofitting approach has become popular in China recently, which focuses on reducing the iron loss in stators and rotors. Directional magnetic wedges are inserted for motors with open slots. Reportedly, this improves motor efficiency by 1-2 percent, which brings a rapid payback on the small investment.

3.54 Major gains in efficiency, however, can only be achieved through changes in the equipment stock. The key is to facilitate the adoption of the most efficient new equipment possible, both to replace old equipment and for use in new capacity. The basic measures to improve the energy efficiency of electrical motor drive applications include:

(a) **Increase Motor Efficiency.** Because electric motors are such an important part of total electricity use, each 1 percent gain in the efficiency of the current stock of motors would reduce the nation's total electricity generation needs by about 0.9 percent. This is roughly equivalent to the output of a typical 1,000 MW power plant.

(b) **Adopt Variable-Speed Motors.** In addition to improvements through increases in the full-load efficiencies of motors, electricity can be saved during partial-load operation by employing motors which can operate at variable speeds. In applications where loads change significantly, variable-speed motors or variable-frequency drives for existing motors can effectively adjust power consumption to match motor loading, resulting in overall efficiency gains.

(c) **Properly Match Motor Size to Equipment Requirements.** There is a tendency in China to use motors (or machines relying on motors) which are oversized for the actual load required. This results in wasted electricity to run the surplus capacity. Motor efficiencies also drop with operation well below full load.

(d) **Improve Coupling Mechanisms.** For freestanding motors, efficiency gains can be made by using efficient coupling equipment, and ensuring that it is properly maintained and adjusted.

3.55 Special priority should be given at this time to improvements in the motors currently produced in China, and the adoption of improved motors in the production of key types of industrial equipment (e.g., integrated blowers, pumps and compressors). Efforts to improve the application of electrical equipment in industry [e.g., (c) and (d) above] are important and need to be steadily supported. However, improvements in the efficiency of motors and associated equipment can be more easily achieved through a targeted program directed at the limited number of producers, with the potential for fairly rapid gains.

3.56 The Government has recently banned production of old J-series motors in favor of the more efficient Y-series. This is a major positive step. Further efforts are required to fully withdraw the J-series motors from production, however, including direct measures such as the enforcement of the relevant standards. These motors are still produced by quite a few factories, in part because consumers are most familiar with them and some types of older equipment cannot be easily adapted to the newer motors.

3.57 In addition, improvements need to be made upon the Y-series motors. Contrary to the claim of some Chinese manufacturers, the energy efficiency of the standard three-phase asynchronous Y-series motors can be substantially improved. At least some of the Y-series motors produced by major Chinese manufacturers conform with International Electrotechnical Commission (IEC) standards, and have electricity efficiency ratings which are at least close to standard levels in the United States (see Table 3.4). However, new, higher-efficiency motors are now commercially sold in North America, Europe and Japan, with efficiencies that are 6.0-8.5 percent higher than both the Chinese high-efficiency and US standard-efficiency models in the lower size range. (Efficiency gains are somewhat less in the larger sizes.) These motors are the wave of the future. In the State of Massachusetts (United States), for example, new efficiency standards are proposed which will require manufacturers to attain these new, higher efficiency levels.

Table 3.4: COMPARISON OF CHINESE AND US ELECTRIC MOTOR EFFICIENCY RATINGS (four-pole closed motors)

	Chinese Y-series motors		US motors (NEMA test procedure)		
Motor size (kW)	IEC test procedure /a	Estimated NEMA test procedure /a	Standard motors	High-efficiency motors	Proposed Mass. efficiency requirement
1.1	78.0	76.0	78.5	84.5	85.5
22	91.5	89.0	-	-	93.6
75	92.7	90.2	91.9	95.0	95.0

/a The IEC test procedure is used to rate motor efficiencies in China, whereas the NEMA procedure is used in the United States. The NEMA test is more stringent—the same motor will usually show a decline in efficiency ratings of 2.0-2.5 percentage points.

Source: Data provided to the mission by Chinese manufacturers and S. Nadel, M. Shepard, S. Greenberg and A.T. Almeida, *Energy-Efficient Motor Systems: A Handbook on Technology, Programs, and Policy Opportunities (1991).*

3.58 **Electric Motor Economics.** The economics of motor operation is such that significant increases in motor cost (if necessary to improve efficiency) can be well justified by what appear to be small percentage gains in electricity costs. Given current Chinese motor prices, the annual electricity cost of operating a motor is orders-of-magnitude higher than the cost of purchasing the motor. For example, a new Y-series 1.1 kW motor was reported to cost Y 270, whereas annual operation for 6,000 hours carries an electricity cost of about Y 1,000-2,000.18/ On a life-basis, motor cost increases of as much as 30 percent are economically

18/ Assumes an electricity price of 15-30 *fen* per kWh.

justified by an improvement in motor efficiency of 1 percent.19/ In the United States, list prices for high-efficiency motors for comparable applications are 20-25 percent higher than for standard efficiency models.

3.59 **Variable-Speed Motors.** A number of Chinese manufacturers now produce variable speed motors (YD or YDT types) The YD motor is a pole-changing multi-speed three-phase asynchronous motor. It has step changes of rotational speed to meet the requirements of load character and is suited for saving energy in mechanical systems. The YDT type is better suited for driving blowers and pumps. Both series are favorably priced compared to fixed load Y-series models. Although their primary efficiency benefit lies with the ability to follow changes in load requirements, the slightly higher full load efficiency 20/ of the variable-speed motors offered alone justifies their adoption, at current prices. One of the key measures which is necessary at this point is for motor producers to work together with downstream manufacturers to integrate these motors with key types of industrial machinery.

3.60 **Recommended Evaluations.** As immediate steps towards strengthening China's efforts to improve the efficiency of the mainstream motors and associated machinery produced in the country, the mission recommends that the following evaluations be undertaken:

(a) On the upstream side, an assessment of the potential for introducing true high efficiency motor designs into Chinese production, through the transfer of state-of-the art international technology.

(b) On the downstream side, an assessment of the electric motor market, including the market for key types of integrated pumps, fans and compressors as well as the market for free-standing motors. Evaluation should consider consumer preferences, pricing issues, and issues relating to coordination among the related manufacturers.

High-Frequency Electric Furnaces

3.61 Electricity consumption in China's 12,000 high-frequency furnaces currently amounts to 50-60 TWh, accounting for roughly 9 percent of electricity generation. Although more work remains, many units have been the target of recent programs to improve furnace efficiencies through retrofit measures. Typical measures include improving furnace insulation (including improvements in refractory bricks and caulking), improving wiring to reduce losses and/or increase heat output, and improving control of the heating process. Major gains also can be achieved through efficient management aimed at maximizing output with a minimum of furnace operation. While the mission did not review the status of furnace manufacturing in China, efficiency gains also may be achieved by building more efficient new units. Officials in Shanghai estimate that in the case of large forging ovens, efficiencies can be improved from the 12-15 percent observed in 1991 to 17-22 percent, an increase of almost 50 percent.

19/ Assumes a lifetime of six years, electricity cost of 25 *fen* per kWh, and a discount rate of 12 percent.

20/ Based on data from a Wuhan manufacturer, a 5.5-kW 6-pole YD motor is 2 percent more efficient at full load and costs Y 66 more than a comparable sized Y-type motor.

Home Appliances

3.62 Home appliances (excluding lights, which were discussed previously) currently account for 4-5 percent of total electricity generation. Electricity use in home appliances grew very rapidly over the 1980s, so that electricity consumption in appliances now accounts for a larger portion of household electricity use than lighting. Households with televisions and refrigerators increased from close to none to over 80 percent of the households in the larger cities between 1982 and 1989. Because much of the growth took place during the last few years, the stock of these appliances tends to be more modern and efficient than in most developing countries. Further, since the supply of electricity in most apartments is constrained by a 3-ampere fuse and 5-ampere wiring, total power use cannot exceed 1,000 watts.21/ Most households thus are accustomed to frugal use of electricity.

3.63 Color TV sets have a rating of about 40 to 50 watts and the commonly used 165 liter refrigerator draws about 70 to 80 watts. Accurate comparison of the efficiency of refrigerators currently produced in China will required further study, as test procedures used in different countries vary substantially.22/ There are some indications of room for improvement in mainstream Chinese models, however. For example, the current 170-liter model produced by Snowflake Corporation in Beijing consumes about 32 kWh/month. In contrast, the Shanghai Aerospace Refrigerator factory is producing a new model (BCD-177A) which reportedly has a consumption of 24 kWh/month.23/

Air Conditioning

3.64 Data currently are not available on the total amounts of electricity consumed for air conditioning in homes and the commercial sector, although the share of air conditioning in total electricity use in 1990 is unquestionably far smaller than in most developing countries. However, the air conditioning sector has raised concern among China's energy policymakers because of recent indications of the likely prospect of explosive growth in the air conditioning load over the 1990s. Given the hot temperatures of much of China during the summer months, the rapid growth in the commercial sector, and the continuing rapid rise in household disposable income, it is worthwhile to pay special attention to this emerging sector.

3.65 Rather than attempt to constrain the development of air conditioning through administrative decrees, the mission recommends that the government focus on improving the energy-efficiency of air conditioning as much as possible. Although the low-ampere wiring of most existing homes will constrain growth in residential air conditioning to some extent, attempts

---

21/ Sathaye J. and Tyler S. (1991). Transitions in Household Energy Use in Urban China, India, the Philippines, Thailand and Hong Kong. *Annual Review of Energy*, 16:295-335.

22/ For example, standard tests of US and Japanese model refrigerators have revealed that using the same US test procedure, the Japanese refrigerators consume 30-50 percent more electricity compared to their Japanese rating.

23/ See Zhang Y., Bi J. and Xiang J. (1991). "The Research and Development of Household Electric Appliances of Low Energy Consumption," in *Proceedings of the Electric Power Conference, July 1991*, Beijing, pp. 292-295. Although there may be distortions from testing procedures, this also compares with a Korean Samsung model refrigerator of the same size which consumes about 20 kWh/month.

to keep the lid on the strong demand that is emerging is likely to fail, as was the case in attempts to constrain the growth in small automobiles during the early 1980s. The nation's needs would better be served by adoption of a well-planned effort to meet emerging demand as efficiently as possible, through (i) review of efficiency levels of equipment currently produced and imported, (ii) adoption of targets, followed by mandatory standards, for energy efficiency levels in new equipment, (iii) initiation of programs to assist manufacturers to meet high-efficiency targets/standards, and (iv) increased attention to improvements in space cooling efficiency in the design and construction of new buildings, potentially backed up through specific provisions in the building codes.

D. IMPROVING THE EFFICIENCY OF COAL USE

3.66 Coal used in industry and electric power generation currently accounts for about three quarters of China's coal consumption, while the residential sector accounts for most of the remainder. Establishment of coal conservation priorities in many ways requires further, in-depth review within each industrial subsector, as part of overall industrial modernization efforts (see para. 3.22). However, there also are more generic types of initiatives. Cross-subsector priorities for the industrial sector identified in the Bank's previous study, *China: Efficiency and Environmental Impact of Coal Use* (March 1991), include (a) improvements in the efficiency of industrial and utility boilers, which together account for over one half of the nation's coal consumption, (b) expanded utilization of waste heat, for cogeneration or industrial process heat applications, and (c) expanded use of industrial plant gases. Improvements in coal quality also are a high priority both for improving energy efficiency and alleviating air pollution in all sectors. Appropriate measures include, expanded washing and selective pelletization or briquetting, but also improved matching of coal quality to user needs.

3.67 Three areas which the mission feels hold particular strategic importance are outlined in further detail below.

Improving Efficiencies in Industrial Boilers

3.68 Major opportunities exist to improve the efficiency of coal use in both utility and industrial boilers. In the case of utility boilers, the principal challenges are to increase scale (primarily through addition of units of 300 and 600 MW and gradual retirement of small units), to incorporate certain technical advancements from abroad, and to improve operating practices. By comparison, improvement in the efficiency of China's industrial boilers is more problematic.

3.69 Unlike in the developed countries, coal completely dominates the production of industrial process steam in China, including steam production in the country's numerous small factories. Some 400,000 coal-fired industrial boilers are currently in use in China. The average capacity is just 2 tons of steam per hour (tph). About 85-90 percent of the stock is under 6 tph, while almost all of the balance is under 20 tph. While some increase in average boiler capacity is expected in the future, radical changes in the structure of boiler demand are not foreseen. Even by the year 2000, industrial coal-fired boilers in the 2-20 tph size are expected to dominate Chinese industry, although the share of boilers in the 6-20 tph class may increase to as much 35 percent of the total. Energy efficiencies are low compared to the 75-80 percent typical in coal-fired boilers abroad. Due both to the small size of the boilers, but also to the technology used, operating practices and problems in coal quality, efficiencies are on the order of 50 percent or less for the smallest units, 50-60 percent for the 1-4 tph range, and perhaps 60-70 percent for the remainder, except for the largest, most modern ones.

3.70 This situation is dramatically different from that in other countries, where coal-fired boilers in these size ranges have been replaced by boilers fired with oil or gas. Coal-fired industrial boiler technology in the developed countries now focuses virtually exclusively on larger units (e.g., over 35 tph). However, coal will continue to dominate in Chinese industry as the basic fuel, due to its abundance and advantages in economic cost. Hence, China continues to be faced with largely unique needs to develop, produce and effectively operate large numbers of relatively small-scale, coal-fired industrial boilers.

3.71 **Design Issues.** While there are also needs to review appropriate applications for fluidized-bed combustion technology, especially for use of poor quality coals, and alternatives (including use of coal gas) for very small boilers, the focus of the Chinese industrial boiler industry must largely remain on stoker boilers. Some of the design areas which appear to have the greatest potential to improve efficiency include (a) development of improved spreader stoker boilers, with improved pollution control features, where greater flexibility to adapt to fuel quality variations is required, (b) reduction in heat losses through better air control, air preheating and thermal insulation, and (c) improvements in (or addition of) boiler controls and instrumentation.

3.72 **Boiler Production Issues.** More than 500 factories produce industrial boilers in China. In most, but especially the smaller ones, production conditions are poor, and a large share of output fails to meet design specifications with respect to rated output and heat efficiency. Specialized manufacturing equipment and tools suited for quality boiler manufacturing are lacking. Although the importance of improving the new boilers being produced in Chinese industry has become well recognized in the central government in recent years, greater action is required. There are insufficient resources and incentives for suitable research and design work, for introducing more efficient designs into production, and for technical renovation of existing manufacturing facilities. Competition is expected to force many of the smaller, more backward factories out of production. In addition, however, the critical process of upgrading production facilities and improving the efficiency of the units produced also could be aided through a strengthening of boiler standards and their enforcement, and investment funding in line with the strategic importance of the sector.

3.73 **Improvements in Operating Practices.** Differences in boiler operator skills can result in variations in boiler efficiency of up to 15 percent. Problems of improper boiler operation are widespread, especially in smaller factories, where boiler operation is typically given to workers with no specialized training. Further strengthening of training programs is an obvious, but important, priority. In addition, greater attention can be given to improvements in the worker bonus systems for operators to include energy conservation bonuses and penalties that are more than just "routine," and are tied more closely to variations in unit consumption (see Annex 3 for a description of these bonuses).

3.74 **Recommended Evaluations.** Two areas where further review is required immediately include:

(a) A detailed study of the structure of future demand for nonutility boilers, including the types and sizes of boilers demanded by different market segments.

An objective market review is needed to set the stage for any strategy to restructure and improve boiler production.

(b) An evaluation of practical options to improve boiler design, based on both international experience and technology, and recent research and design work in China. Building upon the results of the above market study, this effort should provide detailed recommendations on how identified improvements can be implemented within China's existing manufacturing and marketing system.24/

Improving Coal Quality

3.75 Supply of coal of poor quality or inappropriate specification for the applications for which it is used is a major cause of inefficiency (and excessive pollution) in coal use throughout the economy. Some aspects of the problem stem from the low level of coal washing (only 18 percent of China's coal output was washed in 1990) and other problems having to do with inadequate coal preparation. However, much of the problem stems from chronic problems of mismatching between the type of coal supplied and user requirements.

3.76 In the operation of utility and industrial boilers, problems of variation in ash content and size cause consistent problems of mismatching between the coal feed and design specifications. For industrial and heating stoker boilers, problems are exacerbated by the common existence of coal fines in the supply. Another sector for which coal quality problems are especially severe is the urban residential sector. In this case supply of high ash coal, and continued dominance of bituminous coals as opposed to anthracite in many cities, is a key contributing factor to severe low-level air pollution.

3.77 Increased investment in coal washing and some types of pelletization or briquetting schemes for processing coal fines are important parts of the ultimate solution to these problems. However, much can be achieved through improved sorting, screening, and matching of coal varieties to user needs, with minimal investment. The key issue here is further reform of China's coal allocation and pricing system. Much of today's coal market and distribution system is still based on the supply-driven allocation system created decades before, whereby consumers have no choice but to accept what they receive, and cope with it as best they can. While the share of coal bought and sold at market prices has increased greatly, the basic marketing and distribution system has not changed much, especially in major urban centers. With further reforms to increase the share of coal sold through the market at market prices, and to reduce the difference between market and in-plan coal prices, the market and distribution system will need to be reformed. China urgently needs to develop a forward-looking strategy for this reform, focusing on the development of an improved system of coal marketing and distribution which can more effectively and efficiently cater to user needs and a more market-driven pricing system. Success in this area could yield major benefits in terms of raising the efficiency of coal use, with minimal investment in new infrastructure.

24/ These evaluations will be undertaken in a Boiler Efficiency Preinvestment Study, supported under the GEF China Greenhouse Gas Study.

Improving Coal Utilization in the Household Sector

3.78 The residential sector accounted for about 18 percent of total coal consumption in 1990. In contrast to the situation in most other countries, coal is the dominant fuel for urban cooking as well as heating in China. Natural gas and LPG were used to meet only about 9 percent of urban household cooking demand in 1987. Although manufactured gas, primarily based on coal, was used to meet another 4 percent of demand, coal briquettes and raw coal were used to meet the balance, as use of electricity for cooking remains virtually negligible. Although supply of different types of gas to the household sector is expected to increase somewhat over the 1990s, coal will clearly continue to be the dominant fuel into the next century, due to gas supply constraints.

3.79 The primary focus of efforts to improve energy use patterns in the household sector should be placed on improving the quality and level of cooking and heating services, and on reducing environmental pollution. In cooking, important goals include improvements in the convenience of cooking, as well as improvements in cooking efficiency. The main goal of efforts to improve the efficiency of heating systems and building heat retention is to improve the quality of heating services and home heating levels as efficiently as possible. Given the poor heating in most homes today, achievement of actual coal savings at this point does not appear realistic in most cases. Finally, for both cooking and heating, pollution control is an especially important objective. Urban small-scale coal stoves for cooking and heating are a major source of the severe low-level air pollution that plagues most Chinese cities, especially in the northern areas. In addition, indoor emissions of toxic gas and particulates from small coal stoves are serious concerns.

3.80 **Cooking.** Relatively low-cost options to improve coal use in cooking include improvements in coal stoves and briquettes, and improvements in the quality of coal supplied to the sector. Efforts to improve coal stoves and the briquettes which they utilize must consider a variety of objectives in addition to improving combustion efficiencies, including improving turndown capabilities while maintaining convenience of use, reduction of indoor and outdoor emissions, and servicing of hot water and/or space heating demands at the times required. A wide variety of new designs have been developed within China in recent years, but greater promotional efforts would be worthwhile. In the area of household coal supply, major improvements are needed (see para. 3.70). In both efforts to improve stoves/briquettes and coal quality, more attention needs to be given to rural households. Although rural household coal consumption doubled during the 1980s and now approaches the same level as urban consumption, this sector has been ignored in many areas. Coal use by rural households needs to be recognized as legitimate, and use patterns need to be improved through stronger promotion of briquetting and use of improved stoves.

3.81 Expanded use of gas manufactured from coal represents an important means to improve the convenience of urban household cooking and reduce pollution, but it will yield little energy savings if the conversion losses of gasification are considered. Options include further expansion of byproduct coke-oven gas (provided that the coke output can be marketed with reasonable returns), greater use of other byproduct gases from industry, and dedicated facilities for coal gasification, using a variety of technologies.

3.82 **Heating.** The efficiency of heating in residential and commercial buildings can be substantially improved. Existing heating service is also typically poor, both in terms of the level and timing of heat provided and in terms of building heat retention. Options include upgrading of central heating systems, expansion of block heating and district heating, and improvements in building design and insulation. Of these, district heating has received special attention in many municipalities. While district heating can offer major advantages, especially in terms of pollution control, it is however very costly, particularly in cases where it involves a derating of electricity generation capacity of combined heat and power plants. The other options, especially improvements in building design and insulation, have received inadequate support.

3.83 It is well recognized among Chinese experts that building heat losses in China are too large, and could be substantially reduced by improving the thermal insulation of walls and roofs, use of simple passive solar gain design features, and, especially, use of higher quality windows of improved design. Building standards also were put in place in 1986, calling for better insulated housing. The standard calls for reducing energy consumption in residences by 30 percent, with additional building investment of less than or equal to 5 percent. However, the standard has been incorporated in only a few buildings, and has been largely ignored. A primary reason is that government support has not been strong, and the key participants have no direct incentives to improve building heating efficiency.

3.84 Chinese researchers indicate that it is difficult to convince architects and building contractors to incorporate insulation and new design techniques. This has been a problem in most countries because of contractor resistance to new practices and interest in keeping upfront costs low. In China, the shortage of materials and the need for housing magnifies these traditional problems. There is much stronger interest in building more apartments than better insulated housing when investment funds are limited. The focus is on upfront costs, not the total savings which could be realized from a given investment.

3.85 Another factor is that the present system of heating charges provides no incentives to building owners (usually enterprises which invest in housing for their employees) to invest in energy-saving features. Each building is charged for heating according to the floor area, not according to actual heat consumed. In fact, most buildings do not have metering devices. As a result, there are no gains to individual building owners—but there *is* a funding burden—in making larger upfront investments in more efficient buildings. Ultimately, the penalty is paid by the consumer, who receives poor service, and by the country as a whole, in terms of energy waste and pollution.

3.86 Virtually all countries which have made strides in improving the energy efficiency characteristics of buildings have adopted mandatory building regulations to introduce cost-effective energy conservation measures into the housing stock. In China, the government needs to strengthen its role in this area, and adopt a serious program to implement improvements. In addition to continuing technical research and demonstration, key areas to include are: (i) prompt phasing in of mandatory standards for new housing with central or district heating, (ii) promotion of the development of manufacturing capabilities to produce meters, control valves, and insulation materials, (iii) promotion of investment to install meters on old and new housing and modern radiator systems in new housing, and (iv) reform of the current system of heat charges to charges based on consumption and incorporating the full costs of heat supply.25/

25/ Further details are presented in Annex 7, "Building Insulation," of The World Bank, *China: Efficiency and Environmental Impact of Coal Use*, from which much of this section is drawn.

4
THE POLICY FRAMEWORK FOR ENERGY CONSERVATION

4.1 Major improvements and adjustments in China's policy framework for promoting energy conservation will be required for the country to achieve its goals for energy efficiency improvements over the 1990s. During the 1980s, China's government successfully developed a comprehensive set of policy directives, procedures, regulations, technical assistance programs, and project financing initiatives. An extensive institutional network for implementation was established. Some aspects of the existing system for promoting energy conservation are exceptionally strong. However, major weaknesses also exist, especially concerning issues surrounding enterprise incentives for energy efficiency improvement. Moreover, as China's system reforms continue, and the role of the market in the economy continues to expand and become stronger, the nation's energy conservation policies must be adjusted to remain effective. Existing weaknesses will become more and more glaring. The challenge is to be able to adopt needed changes, develop new initiatives and cast aside measures no longer effective, while at the same time keep and further strengthen those aspects of the system which can continue to prove useful and effective in the changing economic environment.

4.2 This chapter seeks to identify and analyze some of the issues surrounding China's existing policy framework for promoting energy conservation, and issues and options concerning future improvement. Although wide issues of system reform, such as enterprise reform, clearly have a major bearing on China's ability to improve overall energy efficiency, this chapter focuses primarily on energy conservation policies in a more specific and narrow sense. The first section provides a brief overview of the current system for promoting energy conservation, and discusses some of its advantages and disadvantages. For those readers who are unfamiliar with China's elaborate existing institutional and policy framework for promoting energy conservation, more details of the mission's understanding of the system are presented in <u>Annex 3</u>. A second section of this chapter provides some observations on more market-based energy conservation policies adopted in a number of other countries. The final section presents the mission's suggestions on how China's system might be improved, in part through a blending of features of the existing system with features tried in other countries.

A. CHINA'S CURRENT ENERGY CONSERVATION POLICY FRAMEWORK

4.3 China's existing energy conservation policies, and the institutional set-up for implementing them, evolved over the course of the 1980s. The system is built upon the basic features of the centrally planned economy, as it existing during the middle 1980s, although adjustments have been made continually over time to adapt at least somewhat to changing conditions. Key organs of the central government—the State Council's Energy Conservation Working Council, the State Planning Commission, and at different times, the State Economic Commission or the State Economic and Trade Office (SETO)—establish the basic energy conservation policies and program directions for the country and oversee the overall implementation effort. Although the industrial line-ministry systems provide important support, especially on subsector technical issues, the details of implementation are undertaken primarily by local governments. Within local government, the planning commissions, economic commissions and industrial bureaus play key roles.

Essential Features of the Current System

4.4 The essential features of the current system are summarized below. Details are provided in Annex 3.

(a) **A Strong Government Planning Role.** Comprehensive and detailed targets, guidelines and standards on enterprise energy consumption levels and energy conservation measures are established at the various levels of the government hierarchy. Monitoring and evaluation of energy efficiency performance, and subsequent negotiation of efforts to improve this performance, are now routine aspects of the relationship between most major enterprises and the government bureaus that manage and supervise them.

(b) **Multiple-Tier Energy Pricing and Manipulation of Energy Supply Quotas.** Prices for energy supplied over-and-above planned quotas are substantially higher than for "in-plan" supply—at different times and places, out-of-plan prices have been even double or triple in-plan prices. Manipulation of in-plan energy supply quotas by government agencies effects both the cost and the stability of enterprise energy supply.1/ It has been one of the most common and favored tools for prodding enterprises to improve energy efficiency.

(c) **Unit Energy Consumption Standards.** Energy consumption standards per physical unit of production (e.g., ton or piece) are set for a wide variety of industrial products. Local governments monitor enterprise compliance through the statistical reporting system and, sometimes, field tests. Major energy-using enterprises also set unit consumption standards for workshops, production lines and/or individual pieces of equipment. Worker compliance is a factor considered in determining worker bonuses.

(d) **Equipment Standards.** Standards specifying minimum energy-efficiency levels have been adopted for specific types of new equipment or appliances. Producer and marketer compliance with some standards is mandatory and appears to be generally well enforced, for example, through publication of lists of banned inefficient equipment. Some, however, appear to be used more as reference standards.

(e) **Investment Funding Facilities.** Specific national and local government funds are set aside for energy conservation projects in the annual and five-year economic plans. These funds are provided to enterprises as loans, with subsidized interest rates. The dominant criteria for appraising conservation

---

1/ Energy supply quota manipulation can take a variety of forms, in addition to cuts in quotas, such as lack of, or only partial, provision of additional in-plan supply to meet energy needs for expanded production, or changes in the quality, source, or transportation arrangements of supply.

projects is the investment cost per unit of sustained energy savings, in TCE per year. Additional funds are provided through regular commercial bank facilities, and by enterprises themselves. State regulations declare that an average of at least 20 percent of the depreciations funds retained by enterprises should be invested in energy conservation projects, on a regional or sector-wide basis. Total energy conservation investment over 1981-90, funded through all sources, was about Y 27 billion.

(f) **Enterprise Performance Awards.** Achievement in energy conservation work is one of the criteria considered in the determination of enterprise performance awards. These awards enable enterprises to obtain priority treatment in a variety of important areas.

(g) **Technical Assistance Facilities.** China has established a network of some 200 energy conservation service centers or stations. The network includes about seven fairly comprehensive training and technical assistance centers, provincial-level centers in virtually every province, and local-level testing and measurement stations.

Advantages of the Current System

4.5 The system which China has developed for promoting energy conservation has undoubtedly succeeded in prodding a wide array of enterprises to undertake technical and managerial measures to improve energy efficiency. Compared to programs in other developing countries, in particular, China's program is now strong in its comprehensive coverage of enterprises, monitoring of consumption practices, promotion of awareness of energy efficiency goals among enterprise managers, and domestic information dissemination. With strong government support, efforts to improve energy efficiency have become a more integral and serious aspect of the energy planning process in China than in most developing countries. These strengths stem from the institutional framework that has been built up by the government, especially during the late 1980s, for overseeing and implementing energy conservation work. This framework consists of a series of national, provincial and county/municipal-level government units (see Annex 3).

4.6 Enterprise energy use trends and unit energy consumption levels are monitored increasingly closely by enterprise managers and supervising government agencies, especially where enterprises are major energy consumers.2/ (At times, however, reported unit consumption figures are just loose estimates, as measurement systems are often crude.) Enterprise managers and supervising agencies now usually know how the unit energy consumption levels of a state-owned enterprise of significant size compare with those of other similar enterprises province- or nationwide. Accordingly, supervising agencies then apply some of the administrative tools described above to try to encourage energy savings. An advantage of this framework, especially given the tendency for wide domestic disparities in China, is an ability to identify enterprises with energy use patterns exceeding established norms, and to apply pressure for improvements accordingly.

2/ 1986 regulations define enterprises which consume 10,000 TCE per year or more as major energy consuming enterprises, but some localities have now widened the definition to include enterprises which consume 5,000 TCE or more.

4.7 Largely due to the institutional framework that is in place, the current system is well set up for the promotion of predetermined generic energy conservation investments on a large scale. Once a given measure has been tried, and demonstrated to be effective, dissemination among relevant enterprises can be rapid, particularly in cases where up-front investment costs are small.

4.8 Recent years also have demonstrated an ability to put in place some energy efficiency standards for energy-using equipment produced by the Chinese machine-building industry. Although it was difficult for the mission to make a meaningful assessment, compliance appears to have been reasonably good, at least for major pieces of capital equipment produced by state-owned enterprises. Bans on the production of obsolete power transformers, for example, seem to have been effective.

4.9 In part because China's energy conservation program has been built upon planned economy concepts, energy demand management has tended to be more closely incorporated in the overall energy planning process than in many countries. Internationally, energy planning concepts which compare units of energy saved with units of energy supplied are relatively new, and are just beginning to be introduced in many countries. Over the last decade, however, these concepts were developed and popularized among energy planners in China, including planners below the national level.3/ This helps provide a solid basis for the further strengthening of efforts to improve energy efficiency, as the equation between energy saved through efficiency improvement and foregone incremental energy supply is already fairly well accepted and taken for granted.

4.10 The prevailing system can provide powerful incentives for enterprises to adopt energy-saving measures. With their ability to influence many of the key parameters affecting the operation of state-owned enterprises, supervising agencies can use administrative measures to exert a great deal of pressure to lower unit energy consumption. The more indirect tool of energy supply quota management, which results in higher energy prices for marginal consumption, also has shown that it can spur enterprises to improve energy efficiency. Particularly in recent years, this often has happened "automatically"—typically (at least in the case of medium and small-sized state-owned enterprises), increases in enterprise output have not been accompanied by increases in in-plan energy supply quotas. When undertaking an expansion in output, enterprises are faced with a need to improve energy efficiency or face high prices and supply insecurity. Many of the industrial energy conservation projects visited by the mission seem to have been induced in this way. Such incentives for energy savings were especially strong between 1987 and early 1989, when industrial output expanded rapidly and energy shortages were particularly severe. Out-of-plan energy prices were exceptionally high during this time (especially for coal), but the difficulties in securing additional energy supplies along the east coast at any price (for electricity as well as coal), encouraged many enterprises to take a second look at energy efficiency measures.

Disadvantages of the Current System

4.11 The chief problem with the current energy conservation program is that enterprise incentives for efficient use of energy remain inadequate. As explained above, there clearly are many cases where enterprises face strong incentives for energy savings. The problem

---

3/ Proper incorporation of principles of Western economics in comparisons of demand management and supply enhancement options, however, is an exception.

is that the administrative measures which underpin the current incentives system are too crude to stimulate proper enterprise responses. The pressure applied to enterprises also is greatly uneven, and for reasons that are arbitrary from an economic point-of-view. The scope of coverage effectively provided is incomplete.

4.12 A natural drawback of the direct administrative measures currently used, such as the imposition of fines for exceeding unit energy consumption standards, is that they are not "automatic," or built into the economic system. Administration is difficult and complicated. Although even and fair application is possible in theory, it is not easy to achieve in practice.

4.13 Use of the energy supply quota management and multiple-track pricing system to encourage improvements in energy efficiency is in some ways more "automatic" or indirect. The system hinges, however, on the level of the in-plan energy supply quotas allocated to given enterprises—the quota level effectively determines the nature of price and supply security incentives at the margin, and how large the higher-price out-of-plan "margin" is if it exists. And, because the quota level is determined administratively, the same types of problems are encountered as with other administrative tools.

4.14 The factors currently determining allocation of in-plan energy supplies among enterprises have little to do with economic efficiency criteria. The industrial enterprises with in-plan supply quotas that cover all or close to all of their requirements tend to be large state-owned enterprises which are designated as key for the national economy or which are relatively old and have not expanded output substantially in recent years. (The latter category also often suffers from energy inefficiency and out-of-date technology.) Blends of in-plan supplies and substantial out-of-plan supplies are common among large, medium and some small state enterprises. However, there are increasing numbers of small and medium-sized state-owned enterprises which have no in-plan allocations, and purchase all of their energy at higher prices. This is particularly the case for new enterprises or enterprises which have undertaken major expansions in regions of recent rapid industrial growth. Finally, there are the rapidly growing urban collective industries and the collectively or individually owned township and village enterprises (TVEs), which as a rule receive no in-plan supplies but must purchase all of their energy needs at higher, market-driven prices.

4.15 Thus current application of the energy supply quota/multiple price system yields major distortions, as the resulting energy cost and supply security variations in a given region are based largely on the age of industrial capacity, enterprise ownership, and enterprise size.

4.16 Another category of incentive-related problems has to do with the inherent difficulties of using direct administrative measures or the quota/multiple price system to provide the right signals on optimal energy efficiency levels to enterprises with very different characteristics. The application of unit energy consumption standards, and assessment of energy supply quotas, fines or special favors accordingly, puts effective pressure on "consumption outliers" to conform to specified norms. This is not the same as providing proper incentives for realizing economically justified energy savings potential.

4.17 With performance evaluation, and associated penalties and favors, focussing upon maintaining consumption below certain broadly applied targets, the incentives provided are to avoid conspicuous waste rather than to truly maximize efficiency. Because the standards are referenced primarily against domestic averages, the tendency is to encourage mediocrity, rather than new innovation. This helps contribute to the trend in China towards marginal modification of prevailing, relatively energy-inefficient industrial technology (even for new capacity), rather than bolder adoption of new approaches or processes. This also contributes to the trend in China to evaluate energy conservation potential through comparison against other enterprises, but rarely through careful analysis of the month-by-month trends *within* an enterprise, as is common in most other countries.

4.18 In addition, energy efficiency standards based on physical criteria (e.g., kilograms of coal equivalent per ton of output) are both imperfect measurements of energy efficiency in a broader, economic sense and may at times bear little relation to economic efficiency. Too much emphasis on their application can create major distortions.

4.19 As stressed in Chapter 2, energy efficiency in an economic sense must consider the value of commodities produced, and not just the quantity produced. To achieve China's goal to reduce the energy required for a given level of economic output, measures that increase the value of commodities produced with the same amount of energy input are just as important as other energy conservation measures.

4.20 Moreover, there are often major differences in the physical levels of energy efficiency that are economically optimal, depending upon the circumstances. An obvious example is variations in the value (economic cost) of the energy in different plants in different regions—the same efficiency level should not be expected in areas with low-cost energy supplies as in high-cost energy supply areas. However, there are also numerous other examples stemming from other factors effecting the costs and benefits of production which may be somewhat less obvious to energy planners. One instance is variations in transport costs, and how these might affect economies of scale, and the resulting variations in energy efficiency. For example, it may be highly efficient from an economic point-of-view to operate a small brick kiln with relatively high unit coal consumption in a mountainous region, rather than rely on transport of bricks from a more distant, but more energy-efficient large brick plant.

B. Market-Based Energy Conservation Programs

4.21 Effective use of energy pricing policy is the backbone of strong energy conservation programs in market-based economies. Although there may be provisions to cushion consumers from short-term fluctuations in international energy prices, the countries which have been most successful in realizing potential for energy efficiency improvements, have, as a rule, adopted pricing policies which pass on to consumers the full costs of energy supply. In addition, many countries add taxes to energy prices (especially imported petroleum products in oil importing countries), to reflect additional perceived costs, such as implied costs in terms of energy supply security or certain environmental costs. Manipulation of these taxes is an important tool used by policy makers to prod consumers to change their consumption patterns.

4.22 A key advantage to the use of energy pricing policy as an indirect tool to influence consumer behavior is that it is "automatic" or built into the economic environment faced by enterprises. As applied in most developed countries, this tool does not suffer from the key disadvantages of the administrative measures discussed above. Signals reflecting the true cost of energy can be provided across the board and fairly to all consumers, with a minimum of administration. Provided that the energy prices correctly reflect costs to the country, their application also will tend to encourage different enterprises to seek energy efficiency levels that are economically optimal for their specific circumstances.

4.23 While policymakers concerned with energy conservation in market-based economies are virtually unanimous in their opinion that energy prices must at least reflect costs, there is less agreement on the extent and nature of additional measures required. However, most members of the international energy community agree that "correct" pricing alone is insufficient to fully foster levels of investment in energy savings that are in the national interest.4/ The need to overcome various "barriers" or market imperfections with additional measures is usually cited (and debated).

4.24 Most countries with successful experience in energy conservation have adopted programs to increase the flow of information to energy consumers about energy-savings measures. These typically include information dissemination and networking programs sponsored by governments or professional associations. A common example is organization of exhibitions of energy-saving technology. Some countries have programs sponsored by government or associations to provide or support energy audits at low or no cost, or to train energy managers or operators of energy-intensive equipment. The United States has adopted a labeling program, which requires manufacturers to prominently display labels on automobiles and key home appliances showing energy efficiency performance through standardized tests and associated life-cycle costs. Another type of effort conducted by some countries, such as the UK, is monitoring programs, which publicize case studies of completed energy conservation projects so that other can learn from the experience.

4.25 Even when consumers are reasonably well-informed, however, experience over the 1980s under a variety of circumstances has shown that consumers tend to require quicker payback periods (and higher rates of return) for investments in energy conservation than for many other types of investment, especially investments in industrial capacity expansion.5/ This is particularly true in cases where energy costs, even at high unit prices, are a small share of total costs. In the many industrial sectors where energy costs are a small portion of total operating costs (e.g., 10 percent or less), even at high prices, energy-saving investments with sound financial life-cycle returns may still go unnoticed, or be considered not worthwhile, because the total costs savings are relatively small and stretched out over a number of years. Similarly, cost savings with little extra investment through energy efficiency gains tend to be overlooked by consumers when purchasing equipment or appliances for which energy operating costs are relatively small (such as electricity-powered industrial machinery or many home electric appliances). Even if life-cycle cost savings are fairly large, and ultimately provide substantial financial benefit to the purchaser, these annual savings often appear trivial in comparison with the total up-front cost of the equipment.6/ Yet, when the potential energy savings of these many seemingly trivial measures are aggregated, they can prove enormous at the national level, and the net costs of these energy savings often are orders-of-magnitude less than the costs of incremental supply.

4/ Investment in energy savings that are in the "national interest" (or economic from the nation's perspective) can be defined as investments which have a lower net cost per unit of energy saved than the cost of equivalent incremental energy supply to the consumer.

5/ See, for example, IEA, *Energy Efficiency and the Environment* (OECD/IEA, 1991) pp. 83 and 99.

6/ For some detailed examples of how consumer and national perspectives can vary, see ESMAP, *The Philippines: Household Energy Strategy Study (1992).*

4.26 Due both to these problems and desires to mitigate environmental impacts of increasing energy use, many countries have adopted additional measures to further encourage energy-saving investment. As in China, some governments have set up special facilities which provide investment funds solely for energy conservation projects. In Japan, for example, these facilities cater especially to smaller enterprises, and offer favorable interest rates. Some countries also provide income or property tax advantages to corporations or individual consumers undertaking conservation investment.

4.27 Some countries, most notably Japan, have adopted government-sponsored programs to increase research and development in energy-saving technology. These programs are designed to provide additional impetus and support for R&D efforts in private firms over and above that provided by market forces. The UK also operates an interesting technology demonstration program, which provides concessional funds for undertaking energy conservation projects based on new ideas. Publication of the results—including negative as well as positive results—is heavily emphasized. Funds are typically provided to a group to monitor the project, as well as to the project's designers and implementors.

4.28 In addition, some countries have adopted administrative-type measures, including equipment standards, building codes, or regulations mandating certain adjustments or programs by private sector companies. Certain energy efficiency requirements, e.g., for building insulation, have been incorporated in the building codes in the United States, Europe and Japan. In the United States, mandatory energy efficiency standards which must be observed by manufacturers and importers have been in place for most of the 1980s for certain equipment, including automobiles, air conditioners, and refrigerators. A number of developing countries with market economies also are exploring this option, particularly to overcome problems of lack of availability of high efficiency equipment in domestic markets, due to import restrictions and lack of suitable domestic manufacturing capability.

4.29 In parts of the United States and Canada, electric power or gas utilities are required to provide special energy conservation incentives or services to their customers. Mandated by the government agencies which regulate the utilities, these activities are usually over and above what the utilities might wish to provide strictly under market conditions.

C. Issues and Options for the 1990s

4.30 Especially with the further progression of system reform through this decade, China needs to make its energy conservation policies more efficient and more responsive to the increasing role of the market. Much of the energy conservation promotion system built up through the 1980s will serve China well in the future; the institutional network, and its increasing capacity to execute serious energy conservation initiatives on a comprehensive scale, provide a critical advantage. Some of the administrative measures which have been relied upon heavily in the past, however, cannot be expected to work effectively or efficiently in a more market-oriented future.

4.31 As the scope of the in-plan economy declines relative to the economy under guidance planning, and the differences between the two are reduced, manipulation of the in-plan energy supply quota/multitier pricing system will become less and less meaningful. While a useful role may continue for the system of unit energy consumption standards, mandatory application of these standards at tighter and tighter levels will run counter to market principles, obfuscate the efficiency advantages of the market, and will prove increasingly difficult to apply and enforce fairly.

4.32 Certain other aspects of the system urgently need to be improved or strengthened. Energy price reform (accompanied by wider enterprise reform) is critical if real progress is to be made in the effort to increase enterprise incentives. Efforts to encourage development, production (or selective importation), and dissemination of more efficient energy-using equipment and processes urgently need to be strengthened, in part through a strengthening of the equipment standards system. Technical assistance and training work needs to be expanded. Methods and mechanisms for allocating investment funds for energy conservation projects need to be reviewed and improved.

4.33 A few of the needs and problems of the future can be seen in the situation of the TVEs, which work primarily within a market framework today. Although there are generic problems of inefficiencies resulting from lack of economies of scale in many of these enterprises, energy efficiency levels in this sector span the full range from highly backward to relatively advanced. These enterprises pay market prices for energy that are generally equal to or greater than supply costs, and they tend to have relatively high motivation to earn profits. In the evidence provided in a recent small ESMAP survey, motivation to conserve energy tends to be high among relatively energy intensive enterprises, at least where market energy prices are at average levels or higher. However, the same type of incentive problems noted in other countries (para. 4.25) seem to exist among some of the producers where energy costs are a small share of operating costs. Generally speaking, however, the greatest problems associated with improving energy efficiency among the TVEs seem to be the low levels of technical and managerial training of staff and low levels of technology, often due to lack of access to better equipment or techniques, and not lack of incentives. Although there have been some attempts to try to impose strict regulations on unit energy consumption levels upon TVEs, this has generally been recognized as impractical. What seems to be required is to strengthen and extend to TVEs other aspects of the energy conservation promotion system, especially training and technical assistance services, and measures to upgrade the efficiency of new equipment being put on the market, in part through progress in the equipment standards system.7/

4.34 The mission's recommendations on improvements in energy conservation policy are provided below in more detail. The mission hopes that these observations will be considered in the preparation of China's new Energy Conservation Law. This law is expected to upgrade the legal status of measures specified in a number of current regulations, and may be promulgated in 1993. The mission was not able to review current drafts.

7/ For more analysis of energy conservation issues among TVEs, see The Joint ESMAP/Chinese Rural Energy Study Team, *China: Training and Technical Assistance in Integrated Rural Energy Development* (1993, forthcoming). This study included a survey of energy use and conservation measures in over 100 TVEs and county-run state enterprises, and additional field interviews, in Huantai County, Shandong; Changshu City, Jiangsu; and Jianyang County, Sichuan.

Energy Price Reform 8/

4.35 Aside from some of the wide, systemic reform measures, energy price reform is the most important single measure needed for improvement of China's energy conservation program. Strong performance in energy conservation during the 1990s will require both greater up-front investment in more energy-efficient process technology and equipment, and a "deepening" of the effort to realize existing enterprise-specific efficiency potential, as opposed to reduction in conspicuous waste and adoption of relatively easy housekeeping measures. Energy price reform is critical for both. In its 1991 field work, the mission noted that this fact is well understood by many of the factory and local government agency officials interviewed, and the slow pace of improvements has been a major source of frustration for those serious about improving energy efficiency.

4.36 Recommended approaches to coal and electricity price reform, which pay proper attention to energy efficiency concerns, are provided in a series of recent Bank reports and documents.9/ Reforms are needed both in price levels (primarily the level and/or role of in-plan prices), and price structure. Very generally, the recommended strategy for coal price reform includes (a) major increases in in-plan coal prices (which applied to perhaps one half of coal use in early 1992) to approximate levels of long-run marginal production and transport costs or international prices (depending upon the type of coal), phased in over a fairly short period (e.g., three years), (b) establishment of certain *temporary* programs to provide relief or additional funds to improve energy efficiency for the subsectors which are hit hardest by coal price increases, and (c) adjustments in relative coal prices to better account for quality differences. Power tariff reform action plans recently supported by the Bank in a number of provinces generally include efforts to (a) continue the movement of average electricity price levels towards long-run marginal cost levels, (b) eliminate current complex tariffs of multitier prices in favor of simpler, more transparent unified tariffs, and (c) reform the structure of tariffs, including the role of demand charges, time-of-day rates, etc.

4.37 **Reform of Price Levels.** As shown in Table 4.1, large differences are typical in many areas between in-plan energy prices and market-driven energy prices outside of the plan. One sector where energy price level problems particularly constrain effective promotion of energy efficiency is in most of the large and medium-sized state-owned industrial enterprises, which often still rely on in-plan prices. Low energy prices reduce interest in improving energy management as a way to reduce costs. Low energy prices also cause many energy conservation investment projects which are economically attractive to the country to be financially unattractive

---

8/ Since the mission's fieldwork, China's program for economic reform accelerated in 1992, including the program for price reform. Market orientation has increased substantially, and the share of traditional in-plan energy supply allocations has fallen further. Average price levels for both coal and electricity also have increased, and the disparity between in-plan and market consumer prices has declined, especially among China's eastern and southern coast. Nevertheless, further progress still needs to be made along the lines described in this section, especially concerning reform of coal prices.

9/ Some of the directly relevant World Bank reports include: *China: East China Power Pricing Study (1988)*; *China: Coal Pricing Study* (1989); Yves Albouy, *Coal Pricing in China—Issues and Reform Strategy* (1991; and *Price Reform in China* (1992). Recently, provincial-level electricity tariff reform action plans have also been established in connection with the Ertan Hydroelectric Project (1991), Yanshi Thermal Power Project (1991), and Zouxian Thermal Power Project (1992). Descriptions can be found in the Staff Appraisal Reports.

Table 4.1: COMPARISON OF CHINESE AND INTERNATIONAL ENERGY PRICES, 1991

	Retail prices (Y/t) /a In-plan	Retail prices (Y/t) /a Outside plan	International prices ($/t)	Estimated border price of potential exports (Y/t) /b
High quality steam coal /c				
Beijing	75-80/d	120-125/d	35/e	186
Shanghai	150-160	170-190	35/e	186
Gasoline	750-900	1,100-1,700	254/f	1,346
Diesel oil	500-700	900-1,300	182/f	965

/a Based on prices quoted by fuel supply bureaus, November 1991.
/b Based on official exchange rate of Y 5.3/$.
/c Low sulfur coal of 6,200-6,500 kilocalories per kilogram.
/d Prices refer to supply from city depots. Factory-gate charges may also include additional highway transport costs. Out-of-plan factory-gate prices in Beijing were reported at about Y 140-150 during the same month.
/e FOB Qinghuangdao, November 1991.
/f FOB Singapore postings, June 1991.

to enterprises—rates of return (or payback periods) are dramatically compromised if the consumer's prices are, say, one half of the actual costs of supply (or the market prices which tend to more closely track actual costs).

4.38 It is true that the large state-owned enterprises also are subject to perhaps the strongest oversight and pressure from the system of energy conservation administrative measures, and that this pressure can yield strong incentives for energy savings. Yet, as argued in paras. 4.11-4.20, it is too difficult to apply these measures to properly stimulate enterprises to undertake the actions which truly realize enterprise-specific potentials for both direct and indirect energy savings. Moreover, the current system heavily relies on the increasingly insufficient supply of subsidized state-allocated investment funds for energy conservation projects, because rates-of-return are artificially low and many of these enterprises are financially strapped. A better arrangement, advocated in the Bank's recent overview of coal price reform strategy, would be to increase in-plan prices fairly rapidly, and utilize a substantial portion of the funds released from reduced state coal subsidies to help finance a temporary, well-targeted program of energy efficiency investments in the hardest-hit heavy industry subsectors.

4.39 In-plan prices also remain dominant for the energy supplied for urban households, and they are particularly low for energy supplied for cooking and heating. This is a key reason for slow progress in the promotion of a variety of measures to both improve energy efficiency and reduce the unacceptably high levels of low-level air pollution emitted by this sector. Implementation of efforts to supply coal of appropriate quality to urban households (e.g., anthracite of reasonable quality for cooking) often is hampered by the implications for government subsidy burdens, given that supply costs are higher but sale prices are rigidly fixed at low rates. Progress in promoting investments in district heating, household gas supply and improved housing insulation is constrained by the poor returns usually offered, due largely to artificially low energy prices. Currently, such investments typically must await large allotments of scarce concessional state funds.

4.40 Although there may be a need to review the number of urban residential price reform issues in an integrated fashion, the burden of higher household energy prices on urban household budgets is small. A doubling in the average price of coal would amount to an increase in household expenditures of 1-2 percent. Consumers also may be very willing to pay higher prices if they could be accompanied by higher quality supply, less pollution (including indoor pollution), and/or better service.

4.41 **Reform of Price Structure.** Aside from other problems and distortions previously noted, such as inequity, the multitier pricing system of different prices for the same energy commodity (or type of service) tends to deflect interest away from energy conservation measures. For an enterprise manager interested in reducing energy costs, increased efforts to manipulate the system may often yield more effective cost savings than increased efforts to improve energy efficiency. Because the current system also is very complicated, and the administrative criteria that define an enterprise's actual energy costs (or their interpretation by supervising agencies) are subject to change, it is often difficult for managers to predict the effective future prices, and hence costs, that they will face. This further reduces interest in energy conservation investment, as the financial benefits are not certain, and hence there is more risk involved. The multitier system has outlived whatever usefulness it had in the past, and continued movement towards unified energy prices is necessary.

4.42 Improvements in the structure of prices to better reflect quality or other key characteristics also would help encourage enterprises to save the energy which is most valuable or costly to society. Examples include greater price differentiation among coal varieties, and improvements and/or further extension of time-of-day or seasonal electricity tariffs.

4.43 **Need for Accompanying Measures.** Price reform needs to be accompanied by broad enterprise reforms to be truly effective. Hard budget constraints at the enterprise level are necessary to develop appropriate interest in reducing all manner of costs, including energy costs. However, price and enterprise reforms alone will not be sufficient for China to achieve the best progress in promoting economically attractive improvements in energy efficiency.

Energy Supply Quotas and Unit Consumption Standards

4.44 As discussed previously, movements toward unified prices and a greater role of the market in the economy will greatly reduce the usefulness of energy supply quota manipulation. This should be recognized in any medium-term view of energy conservation policy and in the process of preparing the Energy Conservation Law.

4.45 The role of unit energy consumption standards in the future program should be carefully considered. These standards are useful as (a) reference points for factory managers and local officials as to how the unit consumption patterns of enterprises compare, and (b) a tool to identify "outlier enterprises" with dramatically inefficient use patterns, compared with others.

However, it seems that local governments are trying to steadily tighten these standards, apply them in greater and greater detail, and increase their enforcement. As discussed in paras. 4.11-4.20, this invites distortions, inequity, and a tendency to achieve only mediocrity in energy efficiency.

4.46 China's energy conservation program is reaching a more sophisticated stage; these crude tools cannot be relied upon to properly encourage enterprises to reach their true energy efficiency potential. The unit energy consumption standards have played, and may continue to play, useful roles by establishing reference points. However, their role should not be expanded. Over the short term, it may be necessary to continue to use these standards as a component of the system of administrative measures to promote energy efficiency, especially among large or medium-sized state enterprises. However, this should be considered as transitory. The mission strongly recommends that the government *not* endorse a policy to rely on mandatory unit energy consumption standards for enterprises as a central tool to try to provide greater enterprise incentives for energy savings. Such a policy would be without precedence internationally (for good reasons), and would run counter to the spirit of reform.

Promotion of Improved Technology and Strengthening Energy-Efficiency Standards for New Equipment 10/

4.47 Even more attention should be given in China's energy conservation program to policies to encourage the production of more energy-efficient equipment, and its expanded adoption among enterprises. When purchasing new equipment to replace out-of-date systems or to expand production capacity, it is critical for enterprises to have access to the most energy efficient, but also cost effective, technology as possible. The equipment and processes adopted by enterprises in the next few years will have a major bearing on energy efficiency levels far into the future, not only because they will be in place for decades, but also because growth in China's industrial capacity is expected to continue to be robust. Yet, the energy-efficiency levels of the equipment and processes typically available for most enterprises still are well below international standards. This is an area where the adoption of appropriate measures in the proposed Energy Conservation Law could be very meaningful.

4.48 Especially during the last 3-5 years, China has made significant progress in developing "high-energy-efficiency" product lines for certain energy-using equipment, and in the banning of equipment models that are particularly inefficient. Yet, the efficiency levels of some types of high energy-efficiency equipment (e.g., electric motors) are significantly below international high-efficiency levels. The mission also observed problems of poor quality in some cases, such as many of the compact fluorescent bulbs being produced. (Poor quality is particularly harmful to the energy conservation effort, as the resulting bad reputation among consumers becomes difficult to overcome.) Finally, higher efficiency models have generally not yet entered the mainstream of the market and continue to account for a relatively small share of the market.

4.49 One area that must be reviewed, and adjustments made where necessary, is the pricing of new "energy-saving" models of certain equipment relative to older models. In its review of key types of electricity-using equipment in 1991, the mission observed a number of cases where the price differences between higher efficiency models, relative to other models, was much greater than the difference in relative production costs. Enterprise managers explained that

10/ Energy efficiency building regulations are briefly discussed in paras. 3.82-3.86.

the profit margins provided on the older, more established but less efficient models were low, due to the low sales prices fixed by the state. Higher profits were being obtained on the high efficiency models, in part to make up for the lower profits obtained elsewhere. It appears that enterprises had greater flexibility to set sales prices for the more efficient models, perhaps due to the fact that they were newer, and less well established. While the behavior of the enterprises was rational, the resulting excessively high *relative* prices of the efficiency models is harmful to the energy conservation effort. The problems caused by such pricing practices will also increase in the future, as orientation towards market forces increases, and, hopefully, the program to increase production of high efficiency model expands. In the cases reviewed by the mission, at least, the problem did not seem to be unfair pricing of the "energy-saving" models, but the irrationally low prices fixed for the older, mainstream models.

4.50 The mission also recommends that the system of setting and enforcing energy-efficiency standards be improved and strengthened, so it can be used properly to push industries to make substantial improvements in the energy efficiency of the "mainstream" equipment models that dominate the market. Although the mission did not review the existing system in detail, the mission's overall impression was that the energy-efficiency standards that are now set for numerous items are in fact submerged within a morass of all types of quality and safety standards, which are applied sporadically and unevenly. They do not appear to have been used as a rigorous policy tool, as, for example, has been the case in the United States. The mission recommends that:

(a) True energy-efficiency standards should be applied only for a selection of key equipment types, but where used, application should be mandatory and rigorous. It may be useful, perhaps, to formulate a special classification for the most important standards, which are then used as a key tool in national energy conservation policy.

(b) The standards should be practical and clear for the industries concerned. They should be stringent enough so that the most inefficient models do not comply, and significant changes must be made, over a reasonable period, in mainstream models. (Otherwise, a given standard serves little purpose, and should not be adopted.) At the same time, the cost ramifications and practicality for industry must be fully considered. Therefore, there must be mechanisms for industry to be closely involved in the formulation process (as appears to already be the case in China). US experience has shown that standards which gradually increase over time are useful.

(c) Pricing policies for the equipment types covered should be explicitly reviewed as part of the process of developing specific standards, in order to ensure that state price regulations are consistent with the energy-efficiency objectives of the standards.

(d) The process of developing, applying and enforcing energy-efficiency standards for equipment should be legitimized (and codified, if possible) in the proposed Energy Conservation Law.

4.51 Finally, greater attention can be paid to energy-efficiency criteria, on a systematic and formal basis, in the investment project approval process. Although improvements have been made, industrial projects which rely on energy-using technologies which have been proven to be wasteful and backward, and have been banned accordingly, often continue to be approved, especially by local authorities, even in areas of great energy shortage. While great leeway must be provided to account for wide variations of local circumstances, it would be useful to further legitimize processes to block such projects.

Strengthening Technical Assistance and Training

4.52 China has made great strides over the last decade in building up capacity to provide enterprises with technical assistance and training in energy management and conservation. Given the enormity of the country's needs, however, further expansion and improvements in the technical assistance and training programs are still urgently required. There are needs to expand both basic energy management training and more detailed technical training catering to specific industries or types of technologies. In terms of coverage, the program in the past has focussed primarily on the relatively large industries. At this point, there is an especially urgent need to expand the effort to provide technical help and training for the numerous smaller enterprises. This includes the TVE sector, where needs and enterprise interests are great, but energy-related technical assistance efforts are way overstretched, where they exist at all.

4.53 Many energy conservation service centers currently lack the measuring equipment and related instrumentation needed to properly conducting technical assistance services, such as energy audits, on the scale required.

Improving Appraisal Criteria for Energy Conservation Investments

4.54 In its allocation of state funds dedicated for energy conservation projects, which are provided primarily on concessional terms, the central government's Energy Conservation Company places primary emphasis in project selection on the sustained energy savings, in TCE, which will result per unit of gross investment, in current *yuan* (or, alternatively, "investment per TCE of energy-savings capacity"). Additional consideration is given to environmental and social benefits. Economic returns are a final consideration, but they are not strongly emphasized. The Company's policy is intended to directly follow the government's objectives for use of the allocated funds, that is, to promote energy savings first, and social and environmental goals second. It is felt that energy conservation projects with good economic returns may best be financed through other channels or with the own funds of enterprises. This overall policy also appears to prevail within local government agencies as well.

4.55 Greater attention should be given to financial and economic return criteria than is currently the case. Clearly, the state currently can provide funding for only a few of the many investment projects which provide substantial energy savings and environmental benefits, and, among the many available projects, economic returns vary substantially. It is also clear that many projects which result in energy savings, environmental benefits and sound economic returns are not able to proceed for lack of financing. There is a strong case, therefore, to make a concerted effort to select the projects with the best economic returns from among the pool of available energy-saving projects with environmental benefits, in order to gain the best possible use of state funds.

4.56 Gross investment per TCE of energy-savings capacity by itself, however, provides very little indication of economic viability. Additional, nonenergy-savings benefits are completely excluded, and the existence of such additional benefits varies dramatically among energy conservation projects.11/ Moreover, the value of the "TCE saved" can vary dramatically, between, for example, electricity supplied during peak load, and coal consumed at minemouth.

4.57 The mission did not have an opportunity to review current practices for the evaluating environmental benefits of different energy conservation projects. In many countries, environmental analysis for such types of projects often amounts to little more than vague assertions of "major benefits." It is important to try to be systematic. Even if monetary values are difficult to derive, the environmental claims of competing projects should be quantified in some sense (e.g., in terms of physical emissions reductions attributable to the project), so that some type of objective comparison can be made.

4.58 To improve the appraisal process for energy conservation projects, the mission suggests that relevant Chinese agencies (a) use the gross investment per TCE of energy savings concept to establish a minimum requirement which all projects must meet to obtain funding from the dedicated facilities, and then (b) use economic rate-of-return criteria (complemented with additional, quantified environmental analysis, where necessary) to select the best projects from the pool of projects that meet the minimum energy-savings requirement. This way, there are assurances that the facility funds will be used to promote projects which yield physical energy savings. However, the rate-of-return criteria can be added as the best way to avoid the problems noted in paras. 4.55-4.56 above.

4.59 A related issue concerns the application of a 1986 regulation that, in energy-deficit areas or energy-intensive sectors, at least 20 percent of the depreciation funds retained by enterprises should be invested in energy saving technical renovations, on a regional or sector-wide basis. To the mission's understanding, this was intended as a broad, macro-level guideline. However, the mission observed a number of cases where this regulation was being applied to individual enterprises.12/ This practice is irrational from an economic point-of-view, and must be strongly discouraged. Across-the-board application of the arbitrary percentage to enterprises with widely different characteristics is not only unfair, but also greatly distorting. When rigidly applied to individual enterprises, it will cause some enterprises which have little potential for undertaking worthwhile energy conservation investments to undertake investments which waste money. It also can be expected to provide little additional incentive to save energy within enterprises with great savings potential, as 20 percent of depreciation funds may be very small compared to what is necessary. "Energy-saving investment" also can be interpreted either widely or narrowly (and hence, unevenly and unfairly).

11/ If costs per unit of energy savings are desired, for example, to compare with costs of supply, it is usually preferable to calculate *net* costs per unit saved. Such a calculation should include (a) subtraction of all quantifiable nonenergy-savings benefits from gross costs, (b) addition to costs of any additional annual operating costs associated with the project, minus any project-related nonenergy savings in annual operating costs, and (c) presentation of both costs *and TCE of energy saved* in present value (discounted) terms.

12/ In response to queries as to why certain energy conservation investments were undertaken, some factory managers replied that the investments were undertaken to meet the 20 percent rule.

Table 1: 1990 COMMERCIAL ENERGY BALANCE SHEET (MTCE)

	COAL	FINE COAL	OTHER WASHED COAL	COKE	CRUDE OIL	FUEL OIL	GASO-LINE	KERO-SENE	DIESEL	LPG	DRY GAS	NATURAL GAS	COKING GAS	OTHER GAS	OTHER OIL PRODUCT	OTHER COKING PRODUCT	HEAT	ELEC-TRICITY	TOTAL
Total Energy Available:	734.5	-4.3	-0.2	-2.5	168.2	0.8	-4.3	-0.6	1.2	-0.1		20.3			-1.8			50.4	961.5
Primary energy output	771.8				197.6							20.3						49.7	1039.4
Import	1.3	0.2			4.2	2.4	0.2	0.4	3.4						0.3			0.8	13.1
Export	-9.9	-3.1		-1.3	-34.3	-1.4	-3.4	-0.8	-2.5	0.0					-2.1			0.0	-58.8
Change in inventory	-28.6	-1.4	-0.2	-1.3	0.7	-0.2	-1.1	-0.2	0.2	0.0									-32.2
Energy Conversion:	-318.8	11.4	13.9	70.5	-158.7	27.8	32.0	5.8	36.2	4.4	4.0	-1.3	9.5	1.1	22.0	2.4	21.4	193.8	-22.6
Thermal power generation	-171.2	-0.1	-3.5		-1.8	-14.0	0.0		-1.8	0.0	-0.1	-1.0	-0.4	0.0	0.0	0.0		193.8	0.0
Heating	-15.3	0.0	-0.1		-0.3	-4.4			0.0	0.0	-0.4	-0.3	-0.6	0.0		0.0	21.4		0.0
Coal washing	-104.4	77.1	17.7																-9.7
Coking	-27.5	-64.0	0.0	70.0									10.3			2.2			-9.1
Refinery					-156.6	46.7	32.0	5.8	38.0	4.5	4.4				22.0				-3.3
Gasification	-0.4	-1.6	-0.2	0.5		-0.6				0.0			0.2	1.2		0.3			-0.6
Losses:					3.6					0.0		0.4	0.0				0.2	33.8	38.2
of which, transport/transmission losses					0.6					0.0		0.2	0.0				0.2	15.8	16.8
Total Final Consumption:	444.5	6.6	11.5	66.5	5.7	29.2	27.9	5.2	37.4	4.3	3.9	18.5	9.5	1.2	20.2	2.4	21.1	210.4	926.1
Productive sectors	305.3	6.6	8.3	66.2	5.7	29.0	21.9	1.8	34.2	1.5	3.9	15.9	8.2	1.0	20.2	2.4	17.6	183.6	733.3
Agriculture	16.0	0.0	0.1	0.6	0.0	0.0	0.8	0.0	8.1									16.7	42.4
Industry	262.0	6.5	7.7	65.5	4.8	25.2	0.9	0.3	0.9	1.3	3.9	14.4	8.2	1.0	20.2	2.4	17.5	157.2	599.9
Construction	3.2	0.0	0.1	0.1	0.8	0.7	0.1	0.0	1.0	0.0		1.4					0.0	2.5	10.0
Transport/post	15.9	0.1	0.4	0.0	0.2	3.0	20.1	1.4	24.2			0.1					0.0	4.2	69.5
Commerce	8.1	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1			0.0	0.0			0.1	3.0	11.6
Non-productive sectors	14.3	0.0	0.6	0.0	0.0	0.2	5.7	1.9	3.2	0.1		0.2	0.1	0.0			0.4	7.9	34.7
Residential consumption	124.9		2.5	0.3			0.3	1.5	0.0	2.7	0.1	2.5	1.2	0.2			3.1	18.8	158.0
Urban	66.7		1.4	0.1			0.2	0.2	0.0	2.7	0.1	2.5	1.2	0.2			3.1	10.7	89.0
Rural	58.3		1.1	0.1			0.0	1.4	0.0									8.2	69.0
Statistical discrepancy	-28.8	0.5	2.2	1.5	0.1	-0.7	-0.2	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-25.4

Source: SSB, China Energy Statistical Yearbook 1991, with adjustments by the mission, including:

(1) Subtraction of power station losses from industry power consumption, and its addition to energy industry losses, according to World Bank practice;

(2) Estimation of gasoline and diesel consumption in own-account transport vehicles in the non-transport sectors, and reallocation to the transport sector as follows:

Re-allocation to transportation of gasoline: agriculture, 65%; industry, commerce and construction, 90%;

Re-allocation to transportation of diesel oil: agriculture, 33%; construction, 50%; industry and commerce, 90%;

Table 2: 1988 COMMERCIAL ENERGY BALANCE SHEET (MTCE)

	COAL	FINE COAL	OTHER WASHED COAL	COKE	CRUDE OIL	FUEL OIL	GASO-LINE	KERO-SENE	DIESEL	LPG	DRY GAS	NATURAL GAS	COKING GAS	OTHER GAS	OTHER OIL PRODUCT	OTHER COKING PRODUCT	HEAT	ELEC-TRICITY	TOTAL
Total Energy Available:	713.7	-2.0	-0.1	-0.8	160.0	0.3	-1.5	-0.4	1.8	0.0		19.0			-1.5			43.9	932.3
Primary energy output	699.9				195.8							19.0						43.3	958.0
Import	1.2			0.0	1.2	1.5	0.3	0.3	3.6						0.4			0.6	9.1
Export	-8.9	-2.9		-1.0	-37.2	-1.2	-1.6	-0.8	-2.1	0.0					-1.9			0.0	-57.7
Change in inventory	21.4	0.9	-0.1	0.2	0.2	-0.1	-0.1	0.1	0.4	0.0									22.9
Energy Conversion:	-271.1	10.4	12.3	58.9	-149.8	26.2	27.8	5.7	33.0	3.9	3.8	-0.9	8.5	0.9	20.7	2.0	16.3	173.1	-18.2
Thermal power generation	-147.3	0.0	-2.8		-3.3	-15.3	0.0		-2.9	0.0	-0.1	-0.8	-0.4	0.0		-0.1		173.1	0.0
Heating	-10.7	0.0	-0.1		-0.2	-3.9			0.0	0.0	-0.1	-0.1	-0.7	0.0	-0.3	0.0	16.3		0.0
Coal washing	-91.9	67.8	15.3																-8.9
Coking	-20.8	-55.9	0.0	58.3									9.4	0.1		1.9			-7.1
Refinery					-146.3	46.0	27.8	5.7	35.8	4.0	4.1				21.1				-1.8
Manufactured Gas	-0.3	-1.5	-0.1	0.6		-0.5							0.2	0.8		0.2			-0.5
Losses:					3.8					0.0	0.0	0.4	0.0				0.2	29.6	33.9
of which, transport/transmission losses					0.4							0.1						15.1	15.5
Total Final Consumption:	441.4	7.6	12.0	58.2	6.5	26.5	25.9	5.3	34.7	3.9	3.8	18.0	8.4	0.9	19.3	2.0	16.1	187.4	877.8
Productive sectors	298.4	7.5	9.5	57.8	6.5	26.4	20.4	1.4	32.0	1.6	3.8	15.9	7.5	0.8	19.3	2.0	13.1	167.3	691.1
Agriculture	18.2	0.0	0.1	0.6	0.0	0.1	0.7	0.0	7.1				0.0					15.0	41.9
Industry	253.6	7.5	8.9	57.1	5.2	23.3	0.8	0.3	0.8	1.5	3.8	14.8	7.5	0.8	19.3	2.0	13.0	143.7	563.9
Construction	3.3	0.0	0.1	0.1	0.9	0.4	0.1	0.0	1.0	0.0		1.0					0.0	2.5	9.4
Transport/post	16.4	0.0	0.4	0.0	0.3	2.6	18.6	1.0	23.0	0.0		0.1					0.0	3.6	66.0
Commerce	6.8	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0		0.0	0.0	0.0			0.0	2.5	9.8
Non-productive sectors	13.5	0.0	0.5	0.0	0.0	0.0	5.3	2.1	2.6	0.1	0.0	0.1	0.1	0.0			0.4	6.6	31.4
Residential consumption	129.5		2.0	0.3			0.2	1.8	0.1	2.3	0.0	2.0	0.8	0.1			2.6	13.6	155.3
Urban	69.2		1.2	0.1			0.2	0.2	0.1	2.3	0.0	2.0	0.8	0.1			2.6	7.7	86.5
Rural	60.2		0.8	0.2			0.1	1.6	0.0									5.9	68.9
Statistical discrepancy	1.2	0.9	0.2	-0.1	0.0	0.0	0.4	0.0	0.1	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.4

Source: SSB, China Energy Statistical Yearbook 1989, with adjustments by the mission, including:

(1) Subtraction of power station losses from industry power consumption, and its addition to energy industry losses, according to World Bank practice;

(2) Estimation of gasoline and diesel consumption in own-account transport vehicles in the non-transport sectors, and reallocation to the transport sector as follows:

Re-allocation to transportation of gasoline: agriculture, 65%; industry, commerce and construction, 90%.

Re-allocation to transportation of diesel oil: agriculture, 33%; construction, 50%; industry and commerce, 90%.

Table 3: INTERNATIONAL COMPARISONS OF THE SHARE OF ELECTRICITY IN FINAL ENERGY CONSUMPTION, 1988 /a
(Percentage of Total Final Consumption)

	Industry/ Construction	Agriculture	Transport/ Post	Commerce/ Services	Residential	Other	Total
Developing Countries:							
China	25.4	39.4	5.3	23.2	3.1	13.3	16.2
Tanzania (1989)	22.7	4.7	0.0	26.9	1.0	0.0	3.2
India (1986)	37.0	96.0	4.2	0.0	3.5	6.5	17.2
Brazil	50.2	33.3	1.1	73.1	25.3	8.0	32.7
Hungary	37.8	29.4	18.7	0.0	29.1	33.6	31.5
Korea, Rep.	39.4	24.6	2.3	73.6	16.7	3.7	28.1
Developed Countries:							
Canada	51.4	52.4	2.2	70.0	68.3	4.5	48.2
France	46.3	14.2	5.7	47.8	65.6	5.7	40.2
Germany	48.9	52.9	6.0	54.6	42.3	10.5	38.1
Japan	53.5	6.5	7.2	61.3	69.5	11.4	45.5
U.K.	42.7	54.6	2.1	72.6	45.7	11.7	36.9
U.S.	39.5	0.0	0.2	70.3	59.3	8.8	37.3

/a Electricity is assigned a thermal replacement value of 2780 kcal/kWh.

Source: World Bank, World Development Report, various years; IEA/OECD, World Energy Statistics and Balances 1985-1988; World Bank country data (Tanzania).

Table 4: INTERNATIONAL COMPARISONS OF THE COMPOSITION OF FINAL ENERGY CONSUMPTION, 1988
(Percentage of Total Final Consumption)

	Industry/ Construction	Agriculture	Transport/ Post	Commerce/ Services	Residential	Other
Developing Countries:						
China	49.7	3.3	5.8	0.9	37.5	2.7
Tanzania (89)	8.3	3.3	3.9	1.2	83.3	0.0
India (86)	27.7	3.1	9.5	0.0	57.0	2.7
Brazil	40.2	3.4	19.6	5.3	29.0	2.6
Hungary	41.4	7.1	8.9	0.0	28.1	14.5
Korea, Rep.	45.0	2.0	15.6	6.1	30.3	1.0
Developed Countries:						
Canada	40.4	1.9	17.8	17.2	20.6	2.2
France	33.6	1.8	21.3	21.1	19.9	2.3
Germany	37.4	1.4	18.9	14.4	23.8	4.0
Japan	49.5	1.5	17.1	10.8	15.9	5.2
U.K.	31.1	1.0	22.0	13.5	28.1	4.3
U.S.	30.6	0.9	26.0	16.8	22.5	3.3

Source: Same as Table 3.

Table 5: INTERNATIONAL COMPARISONS OF PER CAPITA FINAL ENERGY CONSUMPTION, 1988
(Kilograms of Oil Equivalent Per Person)

	Industry/ Construction	Transport/ Post	Residential	Other	Total
Developing Countries:					
China	370	43	279	52	743
Tanzania (89)	34	16	339	18	407
India (86)	86	29	177	18	311
Brazil	430	209	310	121	1,070
Hungary	1,098	236	745	571	2,650
Korea, Rep.	777	270	524	157	1,727
Developed Countries:					
Canada	3,704	1,634	1,889	1,952	9,179
France	1,172	743	692	878	3,485
Germany	1,643	832	1,047	872	4,394
Japan	1,644	569	528	578	3,318
U.K.	1,088	770	984	658	3,499
U.S.	2,309	1,958	1,694	1,580	7,541

Source: Same as Table 3.

Table 6: INTERNATIONAL COMPARISONS OF PER CAPITA FINAL ELECTRICITY CONSUMPTION, 1988
(Kilograms of Oil Equivalent Per Person)

	Industry/ Construction	Transport/ Post	Residential	Other	Total
Developing Countries:					
China	94	2	9	15	121
Tanzania (89)	8	0	3	2	13
India (86)	32	1	6	14	53
Brazil	216	2	78	53	349
Hungary	415	44	217	159	834
Korea, Rep.	306	6	87	85	485
Developed Countries:					
Canada	1,902	36	1,289	1,197	4,425
France	542	42	454	361	1,400
Germany	803	50	443	379	1,674
Japan	880	41	366	222	1,509
U.K.	464	16	450	362	1,291
U.S.	913	4	1,004	890	2,811

Source: Same as Table 3.

Table 7: INTERNATIONAL COMPARISONS OF PER CAPITA FINAL CONSUMPTION OF NON-ELECTRICITY FUELS, 1988 (Kilograms of Oil Equivalent Per Person)

	Industry/ Construction	Transport/ Post	Residential	Other	Total
Developing Countries:					
China	276	41	270	36	623
Tanzania (89)	26	16	336	16	394
India (86)	54	28	171	4	258
Brazil	214	207	232	67	720
Hungary	683	192	528	412	1,816
Korea, Rep.	470	264	436	72	1,242
Developed Countries:					
Canada	1,802	1,598	600	755	4,754
France	630	701	238	516	2,085
Germany	840	783	604	493	2,720
Japan	764	528	161	356	1,809
U.K.	623	754	535	296	2,208
U.S.	1,397	1,953	689	691	4,730

Source: Same as Table 3.

Table 8: INTERNATIONAL COMPARISONS OF THE COMPOSITION OF FINAL ELECTRICITY CONSUMPTION, 1988
(Percentage of Total Final Consumption)

	Industry/ Construction	Agriculture	Transport/ Post	Commerce/ Services	Residential	Other
Developing Countries:						
China	78.0	8.0	1.9	1.3	7.3	3.5
Tanzania (89)	59.8	4.9	0.0	9.8	25.5	0.0
India (86)	59.7	17.1	2.3	0.0	11.6	9.3
Brazil	61.7	3.5	0.6	11.8	22.4	0.0
Hungary	49.7	6.6	5.3	0.0	26.0	12.4
Korea, Rep.	63 1	1.8	1.3	15.8	18.0	0.0
Developed Countries:						
Canada	43.0	2.1	0.8	25.0	29.1	0.0
France	38.8	0.6	3.0	25.2	32.4	0.0
Germany	48.0	2.0	3.0	20.6	26.5	0.0
Japan	58.3	0.2	2.7	14.5	24.3	0.0
U.K.	35.9	1.5	1.2	26.5	34.8	0.0
U.S.	32.5	0.0	0.2	31.6	35.7	0.0

Source: Same as Table 3.

Table 9: INTERNATIONAL COMPARISONS OF THE STRUCTURE OF GDP, 1988
(Percentage of Total GDP)

	Agriculture	Industry	Services, etc.
Developing Countries:			
China	32	46	21
Tanzania	66	7	27
India	32	30	38
Brazil	9	43	49
Hungary	14	37	49
Korea, Rep.	11	43	46
Developed Countries:			
Canada	4	40	56
France	4	37	59
Germany	2	51	47
Japan	3	41	57
U.K.	2	42	56
U.S.	2	33	65

Source: World Bank, World Development Report, 1990.

Table 10: INTERNATIONAL COMPARISONS OF ENERGY INTENSITIES IN INDUSTRY AND AGRICULTURE, 1988
(Kilograms of Oil Equivalent Per 1980 $ Estimated Contribution to GDP)

	Industry/ Construction	Agriculture
Developing Countries:		
China	1.38	0.13
Brazil	0.48	0.19
India (86)	1.11	0.11
Korea, Rep.	0.61	0.11
Developed Countries:		
Canada	0.73	0.35
France	0.24	0.11
Germany	0.21	0.20
Japan	0.35	0.14
U.K.	0.23	0.16
U.S.	0.51	0.25

Source: Same as Table 3.

Table 11: INTERNATIONAL COMPARISONS OF THE STRUCTURE OF MINING AND MANUFACTURING GROSS OUTPUT VALUE /a
(Percentage of Total Mining and Manufacturing Gross Output Value)

		Food	Textiles	Building Materials	Chemicals	Metallurgy	Machine Building
ISIC Number		31	321	362,369	351,352 355,356	37	381-385
China	1980	14.1	16.7	4.5	13.1	10.9	25.9
	1988	11.7	14.8	5.2	14.3	9.5	26.1
U.S.	1980	16.2	3.4	2.7	12.8	7.7	41.0
	1988	14.6	2.8	2.3	13.7	5.8	40.1
Japan	1980	12.1	4.4	3.8	12.9	12.0	40.3
	1988	9.3	3.0	3.0	12.1	9.6	49.8
France	1980	20.1	3.9	3.0	14.2	8.8	35.4
	1988	21.4	3.0	2.6	17.1	7.2	34.0
Germany, F.R.	1980	13.5	3.3	3.4	15.7	9.8	42.1
	1988	13.0	2.7	2.6	16.5	8.9	44.8
U.K.	1980	22.0	3.4	3.4	13.8	7.2	35.6
	1988	20.0	2.9	3.3	15.5	7.2	34.8
Brazil	1978	17.6	6.7	4.0	21.3	13.2	21.4
	1988	17.9	5.6	3.4	24.2	11.9	17.3
India	1978	20.4	18.6	3.0	17.2	12.7	21.0
	1988	17.3	11.4	3.2	21.5	12.4	25.6
South Korea	1980	15.6	14.3	4.8	17.0	10.6	21.9
	1988	10.7	8.6	3.7	13.9	9.5	42.9
Philippines	1979	36.4	9.0	4.3	13.7	4.6	14.7
	1988	33.9	6.7	3.0	9.0	1.9	37.7
Turkey	1979	21.6	16.1	4.7	15.5	11.5	22.0
	1988	18.8	17.5	3.6	17.3	13.9	25.5

/a Energy industries are not included.

Source: The UN Yearbook of Industrial Statistics, 1988.

Table 1: ANNUAL FINAL COMMERCIAL ENERGY CONSUMPTION (MTCE), 1980-90

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Material Production	453.0	442.1	464.1	494.9	531.1	567.5	601.5	646.2	691.1	724.2	733.5
Agriculture	30.5	30.6	31.3	32.1	34.1	36.2	37.7	39.7	41.9	42.1	42.3
Construction	8.3	6.7	7.3	8.1	8.6	11.1	10.1	10.3	9.4	10.4	10.0
Transport/Post	43.1	43.1	45.2	47.4	50.7	56.2	60.5	63.2	66.1	68.2	71.5
Commerce	4.8	5.5	5.8	6.5	7.5	7.2	7.6	8.3	9.8	11.0	10.9
Industry	366.3	356.3	374.5	400.8	430.2	456.8	485.6	524.6	564.0	592.6	598.2
Non-Material Production	18.3	17.9	18.6	20.2	21.6	24.6	25.4	27.5	31.4	33.4	34.7
Household Use	95.8	100.6	103.1	109.1	117.6	133.2	135.8	143.2	155.3	155.8	158.0
Urban	n.a.	n.a.	n.a.	n.a.	n.a.	75.5	78.6	81.2	86.5	86.4	89.0
Rural	n.a.	n.a.	n.a.	n.a.	n.a.	57.7	57.3	62.1	68.9	69.4	69.0
Total Final Consumption	567.1	560.7	585.8	624.1	670.3	725.3	762.7	816.9	877.9	913.4	926.2
Energy Industry Loss	35.7	33.8	34.9	36.2	38.7	41.5	45.8	49.5	52.1	56.0	60.9
Statitical Discrepancy	12.8	14.6	14.0	8.8	13.5	9.2	10.1	5.1	2.4	-16.1	-25.7
Total Primary Energy	615.6	609.1	634.7	669.2	722.5	776.0	818.6	871.4	932.3	953.3	961.5

Source: Mission estimate based on SSB data.

Table 2: ANNUAL FINAL ELECTRICITY CONSUMPTION (TWH), 1980-90

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Material Production	239.6	245.1	260.9	279.9	298.8	320.5	350.6	385.7	421.4	447.8	468.4
Agriculture	27.0	28.2	28.6	28.6	28.8	31.7	32.2	36.0	37.9	41.1	42.7
Construction	4.7	4.7	5.0	5.3	5.8	7.1	5.4	5.8	6.3	6.5	6.5
Transport/Post	2.7	2.9	3.0	3.6	4.1	6.3	6.7	7.7	9.0	9.9	10.6
Commerce	1.7	1.9	2.0	2.4	2.9	3.8	4.1	4.9	6.3	6.9	7.6
Industry	203.5	207.5	222.2	240.0	257.1	271.5	302.3	331.3	362.0	383.5	401.0
Light	n.a.	n.a.	n.a.	n.a.	n.a.	59.5	65.8	74.2	85.0	86.7	90.7
Heavy	n.a.	n.a.	n.a.	n.a.	n.a.	212.0	236.5	257.1	277.1	296.8	310.3
Non-Material Production	6.9	7.4	8.2	9.0	10.1	12	12.7	14.9	16.5	18.1	20.2
Household Use	10.5	11.8	12.1	13.7	15.9	22.3	24.8	28.7	34.3	39.5	48.1
Urban	n.a.	n.a.	n.a.	n.a.	n.a.	12.3	14.4	16.2	19.4	22.5	27.2
Rural	n.a.	n.a.	n.a.	n.a.	n.a.	10.0	10.4	12.4	14.9	17.0	20.9
Total Final Consumption	257.0	264.3	281.1	302.6	324.7	355.0	388.1	429.3	472.3	505.4	536.7
Energy Industry Loss	43.6	45.3	46.9	49.3	53.0	56.8	62.7	69.2	74.4	81.2	86.3
Total Consumption	300.6	309.6	328.0	351.9	377.8	411.8	450.7	498.5	546.7	586.5	623.0

Source: Mission estimate based on SSB data.

Table 3: ANNUAL ENERGY SAVINGS RELATIVE TO TOTAL NATIONAL INCOME, 1981-90
(National Income in Constant 1980 Prices)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Electricity (TWH/Billion Yuan)										
Material Production	5.66	5.19	6.48	18.87	19.14	-5.51	0.57	7.83	-12.53	0.99
Agriculture	0.10	1.93	2.80	3.66	1.05	1.98	-0.50	2.13	-1.91	0.35
Construction	0.27	0.06	0.22	0.21	-0.56	2.32	0.05	0.23	-0.04	0.33
Transport/Post	-0.14	0.17	-0.30	-0.08	-1.63	0.14	-0.30	-0.41	-0.63	-0.24
Commerce	-0.15	0.04	-0.16	-0.16	-0.54	-0.03	-0.37	-0.79	-0.41	-0.42
Industry	5.58	2.99	3.91	15.24	20.82	-9.91	1.68	6.67	-9.54	0.97
Non-Material Production	-0.18	-0.15	0.01	0.11	-0.74	0.42	-0.94	0.06	-0.98	-1.32
Household Use	-0.81	0.76	-0.50	-0.33	-4.16	-0.83	-1.34	-2.45	-4.06	-6.66
Total Final Consumption	4.67	5.80	5.98	18.65	14.30	-5.90	-1.72	5.45	-17.57	-6.99
Energy Industry Loss	0.39	2.23	2.25	2.89	3.50	-1.47	-0.25	2.62	-4.28	-1.26
Total Consumption	5.06	8.03	8.24	21.54	17.74	-7.37	-1.97	8.07	-21.85	-8.25
Total Commercial Energy (MTCE/Billion Yuan)										
Material Production	31.98	15.88	14.61	30.48	36.32	9.54	16.51	27.96	-10.33	25.65
Agriculture	1.37	1.97	2.17	2.33	2.63	1.24	1.83	2.36	1.15	1.31
Construction	1.99	-0.01	-0.08	0.56	-1.38	1.91	0.82	2.06	-0.67	0.89
Transport/Post	1.98	1.58	2.23	3.07	1.46	0.01	3.41	4.26	0.08	-0.08
Commerce	-0.41	0.10	-0.11	-0.09	1.31	0.13	0.08	-0.52	-0.84	0.59
Industry	27.05	12.25	10.39	24.60	32.30	6.25	10.38	19.79	-10.04	22.93
Non-Material Production	1.19	0.84	0.26	1.28	-0.06	1.14	0.50	-0.83	-0.94	0.27
Household Use	-0.34	6.11	4.12	6.18	0.55	7.56	6.42	4.04	4.62	5.35
Total Final Consumption	32.83	22.83	18.98	37.94	36.81	18.24	23.43	31.18	-6.65	31.27
Energy Industry Loss	3.55	1.81	2.02	2.43	2.52	-1.13	1.00	2.88	-2.18	-2.24
Statistical Discrepancy	-1.17	1.85	6.54	-3.47	6.12	-0.14	5.95	3.33	18.54	8.80
Total Consumption	35.21	26.48	27.54	36.90	45.45	16.97	30.37	37.39	9.71	37.83

Source: Mission estimates based on SSB data.

Table 4: TOTAL ENERGY SAVINGS RELATIVE TO TOTAL NATIONAL INCOME, 6TH AND 7TH FYP
(National Income in Billions of Constant 1980 Yuan)

	Sixth FYP 1981-1985		Seventh FYP 1986-90		Total 1980s	
	MTCE	% of Total	MTCE	% of Total	MTCE	% of Total
ELECTRICITY						
Material Production	26.20	89.2%	-0.71	8.1%	25.49	124.3%
Agriculture	4.27	14.5%	1.06	-12.0%	5.33	26.0%
Construction	0.16	0.5%	1.19	-13.4%	1.35	6.6%
Transport/Post	-0.74	-2.5%	-0.51	5.8%	-1.25	-6.1%
Commerce	-0.35	-1.2%	-0.76	8.6%	-1.11	-5.4%
Industry	22.87	77.9%	-1.69	19.1%	21.18	103.2%
Non-Material Production	-0.26	-0.9%	-0.98	11.0%	-1.24	-6.0%
Household Use	-1.82	-6.2%	-5.82	65.8%	-7.64	-37.3%
Total Final Consumption	24.12	82.1%	-7.51	84.9%	16.61	81.0%
Energy Industry Loss	5.24	17.9%	-1.34	15.1%	3.90	19.0%
Total Consumption	29.36	100.0%	-8.85	100.0%	20.51	100.0%
NON-ELECTRICITY FUELS						
Material Production	103.03	72.4%	70.04	49.6%	173.07	61.1%
Agriculture	6.20	4.4%	6.82	4.8%	13.02	4.6%
Construction	0.92	0.6%	3.83	2.7%	4.75	1.7%
Transport/Post	11.06	7.8%	8.20	5.8%	19.26	6.8%
Commerce	1.15	0.8%	0.19	0.1%	1.35	0.5%
Industry	83.70	58.9%	51.00	36.1%	134.70	47.5%
Non-Material Production	3.76	2.6%	1.11	0.8%	4.87	1.7%
Household Use	18.44	13.0%	33.82	24.0%	52.26	18.4%
Total Final Consumption	125.24	88.1%	104.97	74.4%	230.20	81.2%
Energy Industry Loss	7.12	5.0%	-0.32	-0.2%	6.80	2.4%
Statistical Discrepancy	9.86	6.9%	36.47	25.8%	46.33	16.4%
Total Consumption	142.22	100.0%	141.11	100.0%	283.33	100.0%
TOTAL COMMERCIAL ENERGY						
Meterial Production	129.24	75.3%	69.33	52.4%	198.56	65.4%
Agriculture	10.47	6.1%	7.89	6.0%	18.35	6.0%
Construction	1.08	0.6%	5.01	3.8%	6.10	2.0%
Transport/Post	10.32	6.0%	7.68	5.8%	18.01	5.9%
Commerce	0.80	0.5%	-0.56	-0.4%	0.23	0.1%
Industry	106.57	62.1%	49.31	37.3%	155.87	51.3%
Non-Material Production	3.50	2.0%	0.13	0.1%	3.63	1.2%
Household Use	16.62	9.7%	28.00	21.2%	44.62	14.7%
Total Final Consumption	149.36	87.0%	97.46	.3.7%	246.82	81.2%
Energy Industry Loss	12.36	7.2%	-1.66	-1.3%	10.70	3.5%
Statistical Discrepancy	9.86	5.7%	36.47	27.6%	46.33	15.2%
Total Consumption	171.58	100.0%	132.26	100.0%	303.84	100.0%

/a The convertion factor for electricity from TWH to MTCE changes from year to year. as thermal replacement values are used.

Source: Mission estimate based on SSB data.

Table 5: STRUCTURE OF NATIONAL INCOME AND ENERGY SAVINGS DUE TO STRUCTURAL CHANGE AMONG MAJOR PRODUCTION SECTORS

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
STRUCTURE OF NATIONAL INCOME (In Constant 1980 Prices)											
Agriculture	36.0%	36.8%	37.9%	37.4%	37.2%	33.7%	32.2%	30.5%	28.0%	28.0%	28.7%
Construction	5.0%	4.9%	4.8%	5.0%	5.0%	5.4%	5.9%	6.1%	5.9%	5.2%	5.0%
Transportation	3.4%	3.4%	3.6%	3.5%	3.4%	3.7%	3.8%	3.9%	3.9%	4.0%	3.9%
Commerce	6.7%	7.5%	7.4%	7.6%	7.5%	7.8%	7.7%	7.9%	7.7%	6.9%	6.1%
Industry	48.9%	47.4%	46.3%	46.5%	46.9%	49.5%	50.3%	51.6%	54.5%	55.9%	56.3%
STRUCTURAL ENERGY SAVINGS (MTCE)											
Agriculture		-0.69	-0.96	0.48	0.21	3.76	1.71	2.17	3.72	0.03	-1.07
Construction		0.13	0.23	-0.37	0.03	-0.85	-0.84	-0.28	0.29	1.33	0.48
Transport/Post		0.62	-2.68	1.39	0.44	-4.15	-1.98	-0.69	-0.02	-1.06	1.26
Commerce		-0.59	0.09	-0.18	0.14	-0.26	0.04	-0.16	0.20	1.27	1.37
Industry		11.32	8.97	-1.90	-3.79	-23.40	-8.44	-13.24	-29.32	-15.12	-3.86
Total		10.78	5.65	-0.59	-2.97	-24.90	-9.52	-12.21	-25.13	-13.55	-1.81

Source: Mission estimates based on SSB data.

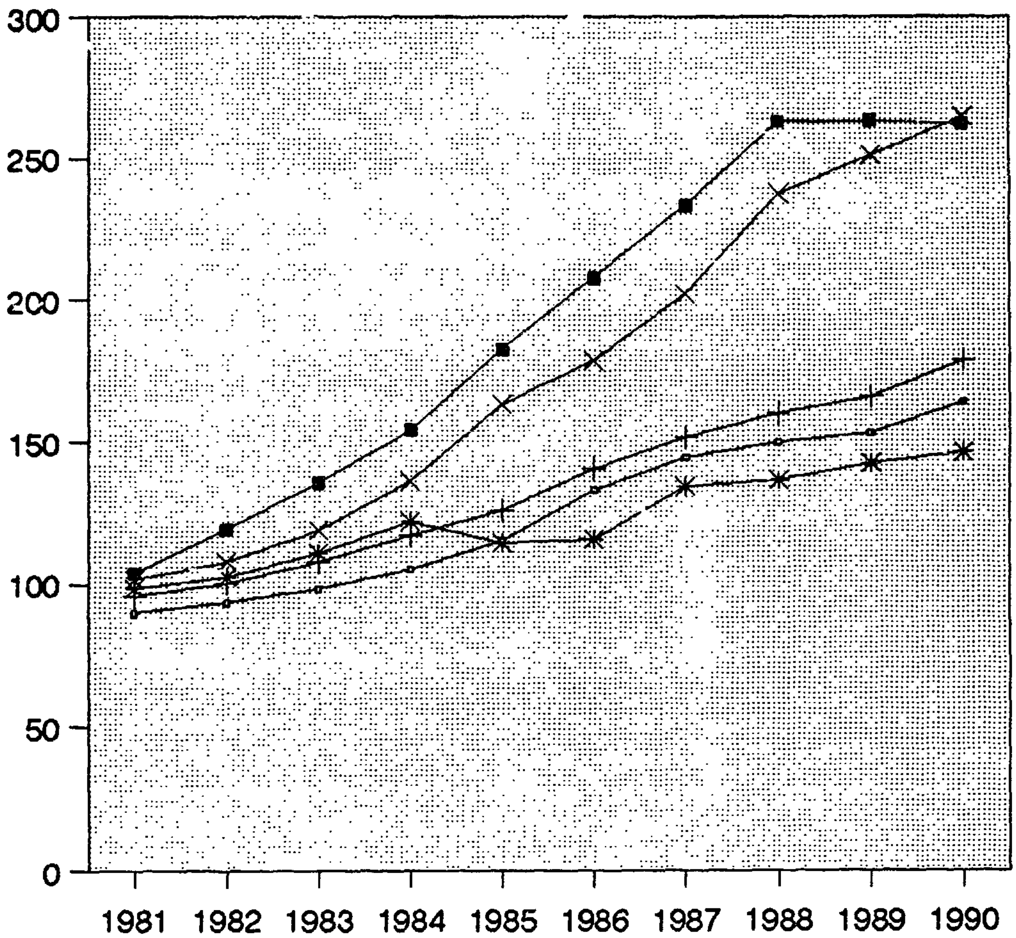
Table 6: ENERGY USE PER UNIT CONTRIBUTION TO NATIONAL INCOME, 1980-90
(Energy Use per Thousand 1980 Yuan)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
ELECTRICITY (KWH)											
Material Production	650	635	623	608	572	540	549	548	538	553	552
Agriculture	204	198	180	167	149	159	156	167	172	181	175
Construction	255	245	250	229	222	223	142	137	136	155	154
Transport/Post	210	224	199	224	230	287	272	280	293	308	321
Commerce	68	66	65	68	74	83	84	89	103	123	146
Industry	1,128	1,134	1,145	1,122	1,050	925	939	911	848	848	840
All Uses (Final Energy)	697	685	671	658	622	598	607	610	603	625	633
All Uses (Primary Energy)	815	802	783	765	724	694	705	708	698	725	735
TOTAL COMMERCIAL ENERGY (KGCE)											
Material Production	1,228	1,145	1,108	1,076	1,017	956	941	918	882	895	865
Agriculture	230	216	197	187	176	181	183	185	191	186	176
Construction	448	352	363	350	330	348	268	242	204	246	237
Transport/Post	3,417	3,314	3,012	2,961	2,816	2,542	2,458	2,307	2,166	2,130	2,170
Commerce	196	167	156	138	124	105	98	87	80	87	93
Industry	2,030	1,947	1,930	1,873	1,756	1,556	1,509	1,443	1,321	1,310	1,253
All Uses (Final Energy)	1,538	1,453	1,398	1,357	1,284	1,222	1,194	1,160	1,121	1,129	1,092
All Uses (Primary Energy)	1,669	1,578	1,515	1,455	1,384	1,308	1,281	1,238	1,190	1,178	1,134

Source: Mission estimates based on SSB data.

Figure 1: Basic Materials & Industry Growth Index

(Base Year: 1980=100)



Pig Iron	90	93	98	105	115	133	145	150	153	164
Steel	96	100	108	117	126	141	152	160	166	179
N. Fertilizer	99	102	111	122	114	116	134	137	143	147
Cement	104	119	136	154	183	208	233	263	263	263
Industry	102	108	119	136	163	179	202	237	251	265

Pig Iron + Steel * N. Fertilizer ■ Cement × Industry

Source: SSB, Statistical Yearbook of China 1991. (in Chinese)

CHINA'S INSTITUTIONAL AND POLICY FRAMEWORK FOR ENERGY CONSERVATION

A. INSTITUTIONAL FRAMEWORK

1. China's institutional setup for promotion of energy conservation is among the most extensive in the world. Specialized units for integrated energy conservation work exist at central, provincial, and most prefecture/county government levels. Specialized units also are in place at the various levels within the hierarchies of the line ministries dealing with the chief energy-consuming sectors or subsectors. Generally speaking, the institutional system began to evolve during the early 1980s. Much of the current system then was formally sanctioned within the State Council's "Temporary Regulations for Energy Conservation Management," issued in January 1986 (see para. 27-29). While there has been some change during the last five years, following wider organizational changes in the Government, these changes have been mostly cosmetic, rather than substantive.

Central Government Institutions

2. Basic policy directions for energy conservation are set by the State Council. They are announced and discussed at meetings of the State Council's Energy Conservation Working Council (*jieneng bangong huiyi*). The council meets approximately once a year. The Council is chaired by a Vice Premier, and includes the Minister of Energy and Vice Ministers of the industrial ministries. The Sixth Meeting of the Council took place in December 1990, and was chaired by Vice Premier and Minister of the State Planning Commission, Zou Jiahua.

3. Coordination of the nation's energy conservation program, including overall policy implementation, investment allocation and day-to-day management, has been conducted by the State Planning Commission (SPC) and also, at different times, the State Economic Commission (SEC) or State Economic and Trade Office (SETO). Until the Government reorganization of 1988, the Energy Conservation Bureau of the SPC was in charge of the annual and five-year planning for conservation work and the allocation of funds for capital construction energy conservation projects, while the Energy Bureau of the SEC was in charge of energy conservation management activities (e.g., promotion of energy conservation initiatives through energy supply quota management, etc.) and the allocation of funds for technical renovation

energy conservation projects.1/ During 1988-91, the SEC functions were merged within the SPC, and responsibility for coordinating all aspects of the nation's energy conservation program rested with the Department of Resource Savings and Comprehensive Utilization of the SPC. In the Fall of 1991, however, a new Bureau of Resource Savings and Comprehensive Utilization was being established in the State Economic and Trade Office, which is expected to have responsibilities for energy conservation work similar to that in the old SEC (e.g. day-to-day management and investment allocation for technical renovation projects.

4. in mid-1991, the Department of Resource Savings and Comprehensive Utilization of the SPC maintained a staff of 23 professionals. It includes five divisions: Energy Conservation, Raw Materials Conservation, Rural Energy, Comprehensive Planning, and Administration (*zonghechu*).

5. Under the overall guidance of the SPC, the Energy Conservation Company of the State Energy Investment Corporation (EEC) is responsible for the detailed appraisal and project-by-project approval for energy conservation projects funded with the funds allocated by the SPC (e.g., primarily capital construction project funds). The Corporation had a staff of 19 persons in mid-1991. To conduct its appraisal and approval functions, the Corporation relies on the inputs of provincial agencies, units in the line ministries, and special groups of experts, in addition to their own staff. (See paras. 66-68 for more details.)

6. Also under the purview of the Department of Resource Savings and Comprehensive Utilization of the SPC is the National Petroleum Conservation Office.

7. Within the Ministry of Energy (MOE), the Department of Energy Conservation also plays a role in reviewing and overseeing the nation's energy conservation policies. The Department's special strengths, however, lie in energy conservation in the energy industries, especially the electric power sector. The Department has a professional staff of 16 persons, organized into three divisions.

8. In 1987, the National Electricity Conservation Office was established, in connection with the issuance of "Several Regulations Concerning Further Strengthening of Electricity Conservation". The Office operates under the guidance of the Energy Conservation Working Council, but it has been placed within MOE, together with MOE's Department of Energy Conservation. Also within the MOE are the Office for the Planned Use of Electricity (within the Power Department), and a Division for Safety in Electricity Use. These units together provide the central government technical support and oversight for the Offices of Electricity Allocation, Conservation and Safety ("Three Electricity Offices") found in local government. (There is no specific "Three Electricity Office" at the central government level.)

1/ Funding channels for "capital construction" projects and "technical renovation" projects are distinctly different in China, although the substantive distinction between these two types of projects may at times be less clear. Generally speaking, capital construction projects are projects which focus primarily on the construction of new facilities. Investment requirements are generally larger than for technical renovation projects. In technical renovation projects, investment in civil works is supposed to comprise 30 percent or less of the total investment.

9. Central government authority for the establishment of energy consumption standards for different types of equipment rests with the National Bureau of Technical Control (*Guojia jishujiandu ju*), which is under the State Council. This Bureau combines the functions of the former National Bureau of Standards (*Guojia biaojun ju*) and National Bureau of Measurements (*Guojia jiliang ju*). The Bureau establishes a wide variety of mandatory and reference standards for equipment producers based on recommendations from committees of government and industry experts. The China Energy Units and Management Standardization Committee (*Zhongguo nengyuan jiqu guanli biaojunhua weiyuanhui*) is charged with the responsibility for review and proposal of energy efficiency standards. The committee includes a wider range of subcommittees which have the technical expertise for review of different types of equipment. One example is the Subcommittee for the Rational Use of Electricity, which recommends the standards for electrical appliances. This committee is led primarily by experts from MOE, and meets about once per year.

10. Finally, each of the key line ministries dealing with industry, infrastructure or transportation has an Ministry Energy Conservation Office, dealing with the specific sector or subsector that they are in charge of. In 1991, there were 31 such offices. They play key roles in the preparation of sector/subsector energy conservation plans, technical appraisal of prospective conservation measures and issuance of sector-specific energy consumption and efficiency guidelines and regulations.

Local Government Institutions

11. Local government agencies play key roles in the actual implementation of the nation's energy conservation policies. Generally speaking, the organization of institutions involved in energy conservation work mirrors that of the central government. Integrated agencies charged with overall coordination of energy conservation programs exist within the provincial governments. Underneath them, there is both a partial network of prefecture and county/district integrated energy conservation offices within the prefecture or county/district governments,2/ and a partial network of energy conservation units within the provincial-level sector or subsector-specific departments dealing with industry and infrastructure. It is primarily through these two networks that the government energy conservation institutions directly touch enterprises.

12. As in the central government, it seems that many provinces have formed Provincial Energy Conservation Working Councils, which typically are chaired by a Vice Governor and meet occasionally to formulate policy. Also similar to the central government, coordination of provincial energy conservation programs falls to Provincial Planning Commissions and Provincial Economic Commissions (or, where they are merged, Provincial Planning and Economic Commissions).

13. Provincial Planning Commissions (PPCs) usually include a small group which covers energy conservation concerns in the annual and five-year plans, and the allocation of capital construction project funds. In different provinces, energy conservation responsibilities

---

2/ Local government includes provinces (and municipalities of provincial-level rank, such as Beijing, Shanghai and Tianjin), and under them, prefectures, and then finally counties (rural) or districts (urban).

fall to different PPC divisions, for example, Materials and Energy (e.g., Shanghai), Infrastructure (e.g., Beijing), or Resource Savings and Comprehensive Utilization (e.g., Sichuan or Jiangsu).

14. Typically, the Provincial Economic Commissions (PECs) play an especially important role. They often include a Provincial Energy Conservation Office, which is charged with the day-to-day implementation of energy conservation policies, allocation of technical renovation funds, review and evaluation of new energy-efficient technology, and information dissemination concerning energy conservation. In the case of Beijing Municipality, the Economic Commission's Energy Conservation Office includes a staff of about 10 persons, while in Hubei Province it includes 22.

15. Provincial governments also include Offices for Electricity Allocation, Conservation and Safety ("Three Electricity Offices", or *Sandian bangongshi*). These offices operate under the guidance of the PECs, but also in close cooperation with Provincial Electric Power Bureaus. They are responsible for administration of the power supply quota systems, and arrangements for any increases in enterprise power supply levels. They also oversee electricity conservation work, including efforts to monitor adherence to unit electricity consumption standards and to promote use of more electricity-efficient equipment.

16. Additional provincial-level offices exist for petroleum conservation and for coal conservation. As with the Three Electricity Offices, these offices operate under the guidance of the PECs on substantive matters, but also have administrative links with line bureaus.

17. Also within the provincial governments, bureaus overseeing the major energy-using industrial subsectors or infrastructure sectors have specialized energy conservation units. In Hubei Province, Industry/Infrastructure Bureau Energy Conservation Units of 2-4 persons operate in the bureaus dealing with key energy consuming subsectors, such as the bureaus for electric power, metallurgy, chemical industry, textiles, building materials, light industry, and city construction. In Shanghai, a great deal of the practical implementation aspects of energy conservation work is funneled through these bureau-level units down to the corporation level and then down to the enterprise level. In Shanghai, these units typically include 4-5 persons.

18. The other network which makes a bridge between the provincial-level integrated energy conservation agencies and enterprises is the network of Prefecture and County/District Energy Conservation Units. These units typically include several persons working within the Prefecture-level or County-level Planning and Economic Commission (or Economic Commission, if this exists separately). They concern themselves primarily with county-level state-owned industry and urban/town construction, but may also oversee some efforts to promote energy conservation in collectively-owned industries (e.g., township and village enterprises). In Hubei Province, fifteen prefecture energy conservation offices are operating, with a total staff of about 60 persons, and about one-half of the province's counties have specialized energy conservation offices.

19. In both the bureau-level and the prefecture/county networks, day-to-day responsibilities appear to focus on (a) management of the enterprise energy supply and unit consumption quota systems (see paras. 34-46 below), (b) introduction, demonstration and dissemination of new, more energy-efficient technologies, and (c) review, appraisal and approval

or recommendation (depending upon enterprise level and funding requirements) of energy conservation investment projects.

Enterprises

20. The "Temporary Regulations for Energy Conservation Management" (1986) stipulated that all enterprises which consume 10,000 tons of coal equivalent (TCE) per year or more should designate specific staff with responsibilities for enterprise energy conservation work. In 1991, specialized energy conservation units were operating in all of the major energy consumers visited by this mission. In the case of Hubei and Beijing (and probably many other provinces as well), all enterprises which consume 5,000 TCE or more per year have conservation units. Such enterprises numbered about 500 in the case of Hubei. In both areas, many enterprises with smaller annual consumption levels also had staff specializing in conservation work.

21. Typically, the work of these units includes monitoring of total and unit energy consumption, occasional testing, and proposal of energy conservation regulations and projects. They are in charge of at least the technical aspects of the detailed energy conservation management systems described in paras. 34-46.

Energy Conservation Technical Service Centers

22. A variety of different types of agencies provide enterprises with technical advice and training in energy conservation, and/or assistance in measuring and calculating energy consumption or heat balances. Generally speaking these agencies may be grouped as follows: (a) well-established, regionally-based training and technical assistance centers, (b) provincial/municipal-level technical service companies and (c) provincial (or even prefecture or county) testing and measuring stations.

23. Training and technical assistance centers that provide fairly comprehensive and sophisticated services include centers in Beijing, Chongqing, Harbin, Hangzhou, Nanjing, Shanghai, Tianjin and Xian. Five of these were established as part of a cooperative program with the European Economic Community. At least most of the others also have received some international assistance. These centers play an especially important role in the training of local Government cadres and enterprise managers and technicians in energy auditing, energy conservation technology, and energy management. The center in Nanjing, for example, publishes a monthly magazine in energy conservation technology, and maintains a training center, testing and experimentation facilities and a guest hostel.

24. Another example, the Beijing Energy Conservation Service Company, has been in operation since about 1983, with some technical and financial assistance from the Government of France. It employs about 120 persons. It operates under the guidance of the Municipal Economic Commission's Energy Conservation Office, and it undertakes testing, auditing, and selected research and development, in addition to training. The Company provides services to, and is compensated by, the Municipal Government for medium-term projects and enterprise-level projects which are included in the province's annual economic plan. It also provides independent consulting services to enterprises, upon their request, at negotiated rates. The Municipal Government provides a subsidy of some Y 100,000-200,000 to the Company each year.

25. The Shanghai Energy Conservation Technical Service Center began operation in 1986, and now employs about 63 persons, of which most are engineers. As with the Beijing Company, the Center is compensated in part by the Municipal Government and in part by the industrial agencies, corporations or enterprises for which it conducts its work. Much of the Center's work focuses on inspection of energy consumption patterns in the city's industries, in large part to check compliance with standards. Twelve inspection teams operate under the Center's umbrella, using vehicles obtained from Japan. Over four years, the Center has completed over 2000 inspections, and now is pledged to complete 350 inspections per year. Following these inspections, the enterprises are given a report, discussing compliance with standards and recommendations for future energy conservation efforts. About 35 percent of the enterprises receive warnings on non-compliance with standards, and a few are fined. Although some of the inspection teams have had assignments outside of Shanghai, the Center itself operates only in the Municipality.

26. A total of about 200 energy conservation service centers are reported to be operating nationwide. Of these, 28 are reported as provincial-level. It appears, however, that most of these centers focus primarily on measurement and monitoring, especially to check compliance with standards, as opposed to the more comprehensive services offered in, say, the Nanjing Center. The situation in Hubei Province may be typical. In Hubei, there are a total of 21 units that are engaged in measuring energy consumption patterns and the calculation of enterprise heat balances. Altogether, about 200 persons are employed in this network. The leading center is the Hubei Provincial Monitoring and Measurement Center, which undertakes a wide variety of energy use measurement activities, including the testing of new products and the calculation of heat balances. The latter cost an average of Y 20,000-30,000 per factory. Additional technical consulting services for energy conservation work can be obtained through the provinces's research and design institutes or universities.

B. REGULATIONS AND LEGAL FRAMEWORK

27. The basic framework for implementation of the government's energy conservation policies, including the institutional network described above, and the underpinning of the system of standards, quota management and project funding mechanisms described below, has been established through a series of central government regulations and guidelines. Probably the most important to date is the State Council's "Temporary Regulations for Energy Conservation Management,"3/ issued in January 1986 (hereafter referred to as the "1986 Regulations").

28. The 1986 Regulations established, sanctioned or included instructions for the following:

(a) The basic central, local and enterprise-level specialized institutional framework described previously.

(b) Strengthening of the energy consumption reporting at all levels, from the factory floors of energy-intensive enterprises to national levels.

3/ In this case, "temporary" means that the regulation can be altered if circumstances warrant.

(c) Linking of energy conservation program promotion with energy supply management. This includes instructions to (i) prioritize energy supply allocations based on the level of energy management of enterprises and enterprise unit energy consumption, (ii) improve the quality of coal supplied, and management of the matching of quality with user needs, (iii) link coal quality and price, (iv) more strictly tie electricity allocation to the plan and promote multiple-track electricity pricing, (v) strictly control the use of fuel oil and the use of diesel oil for power generation, and (vi) improve petroleum product distribution infrastructure.

(d) Improving energy management in industry, including instructions for (i) restrictions on development of small-scale energy-intensive operations, such as small thermal power plants, small forgeries, etc., (ii) prohibition of expansion of boiler capacities without prior authorization, (iii) restriction of the development of small coke ovens, and (iv) further promotion of improvements in electricity grids, development of cogeneration, integrated supply of heat or other intermediate products within industrial districts, and use of by-product gases or low-quality fuels.

(e) Improving the efficiency of household energy use, through a variety of efforts, such as improving the quality of coal supplied, and the development of rural energy resources, town gas, and district heating.

(f) Promoting more energy efficient technology through (i) requirements for consideration of rational energy consumption in project feasibility studies, (ii) instructions for enterprises with above-average unit energy consumption to undertake energy conservation technical renovations using depreciation funds, and requirements that at least 20 percent of depreciation funds should be invested in energy saving technical renovations, in energy-deficit areas or energy-intensive sectors, on a regional or sector-wide basis, (iii) provision of subsidized loans, (iv) provision of certain tax breaks for the production of new energy-efficient products, and (v) prohibition of the manufacture or sale of inefficient electro-mechanical products banned by the state, and gradual replacement of such equipment currently being used.

(g) Establishing enterprise awards for energy conservation and a number of penalties for non-compliance with the regulations previously listed, which primarily focus on cutting energy supplies or increasing the cost of supplies.

(h) Promotion of information dissemination and educational activities.

29. Provincial governments also adopted their own versions of these regulations, with some additions based on local conditions. In Shanghai, the Municipal People's Congress has also passed an Energy Conservation Law (in tune with the spirit of the 1986 Regulations), which is reported as the only such law in existence.

30. Over the last decade, a wide range of additional regulations or guidelines have been issued by the State Council, the State Planning Commission or other central coordinating

agencies, line ministries, and local governments. These are generally not publicly published, although they are well known by those concerned. Some examples include the "Temporary Regulations for Electricity Conservation" (issued by the State Council), "Several Provisions for Further Strengthening Electricity Conservation," "Determination of Bonuses for Saving Fuel and Raw Materials," or "Guidelines for Encouraging Cogeneration and Limiting Small Thermal Power Generation."

31. Efforts are now being made to adopt a national Energy Conservation Law. The process of drafting, reviewing and revising is well underway, and approval by the National People's Congress may take place in 1993. Drafts are not publicly available, but much of the content and spirit of the proposed law is reportedly based on the 1986 Regulations, and guidelines closely connected with those regulations.

32. With the passage of a formal law, the legal framework for the nation's energy conservation work would be significantly strengthened beyond the current framework based on the 1986 Regulation. Ability to implement, and especially to enforce, a number of the key elements of the 1986 Regulations has not satisfactorily met the hopes of the country's energy conservation agencies. Difficulties experienced enforcing regulations restricting the development of new industrial capacity based on backward, energy-inefficient technology has been a particular concern. It is hoped that an Energy Conservation Law would improve the framework for implementation and enforcement, mobilize additional support for broad-level initiatives, increase awareness of the strategic importance of improving energy efficiency, and provide a stronger basis for strengthening and legitimizing the institutional framework for conservation work.

C. Energy Consumption Quotas and Standards

33. Although the Government employs a variety of policy instruments in its efforts to promote energy conservation (see Chapter 4), including indirect measures through the pricing system, administrative measures have played a particularly important role to date, either directly, or in coordination with price policy. Principal among the administrative measures are China's systems of energy consumption quotas and standards. These may be broken down into three categories: (a) energy supply quotas, (b) unit energy consumption standards, and (c) equipment standards.

Enterprise Energy Supply Quotas

34. Energy supply quotas are a feature of the centrally planned economy. As the scope and nature of that economy has changed (and continues to change) with reform, the ways in which the energy supply quota system is used as a policy tool also has changed.

35. Traditionally, the enterprise energy supply quota of the planned economy has referred to a fixed amount of fuel or power supply allocated to an enterprise under the annual economic development plan. This is now commonly referred to as the quota for "in-plan supply." Supplies are arranged by the state (traditionally also using "in-plan" transport), at state-fixed "in-plan" prices. These prices are the lowest available, and, during the 1980s, they generally have increased less than the rate of inflation.

36. Particularly during the beginning of the 1980s, manipulation of the energy supply quota system was perhaps the most popular tool of local governments to apply pressure on enterprises to halt energy waste and undertake energy conservation measures. When alternatives to in-plan supply were difficult to arrange, as well as costly, both directly or directly, effective pressure could be applied through cuts (or lack of increases) in supply quotas without corresponding adjustments in enterprise output quotas.

37. With the continuing economic reform, and the development of a mixed planned and market economy, however, a variety of legitimate "out-of-plan" channels of energy supply became available. For the vast majority of enterprises, in-plan energy supply quotas have not changed since the early or middle 1980s, as a matter of government policy. Thus incremental energy supply for expanded output and new capacity has generally come from out-of-plan supply sources.4/ The most important difference between the two is price. Although there are many channels of supply with different prices, out-of-plan energy supplies are typically about double the price of in-plan supplies. In addition, in-plan supply may be more secure in times of severe shortages, as supply is guaranteed or considered high priority by the state.

38. The share of in-plan and of out-of-plan supply for different fuels now varies dramatically between consumers. The general principle is "low in, low out" and "high in, high out", meaning that where the goods produced are sold at low, in-plan prices, these should be produced with low-priced, in-plan energy, but where the goods produced are sold at higher, market-driven prices, in-plan energy should not be provided. Many long-established, relatively large state-owned industrial enterprises still receive the bulk of their energy through the plan. Certified urban residential consumers receive energy for normal household needs under the plan. Except for electricity in some cases, rural households, however, do not receive in-plan energy supplies. Collective enterprises (including the country's large township and village industry sector) must obtain all of their supplies outside of the plan. Then there is the large number of medium and large state-owned industries which may receive some in-plan supplies of certain fuels, based on old quotas, but also must make arrangements for a substantial portion of their needs outside of the plan.

39. Currently, manipulation of the energy supply quota system under the plan can still be used to prod enterprises to save energy, but from the enterprises' perspective the focus is primarily on the in-plan and out-of-plan price differential. Where possible, enterprises would opt to continue to enjoy as much energy supply through the plan as possible, due to the low prices. Similarly, orders to reduce energy consumption or face reductions in in-plan supply carry the threat of higher costs for energy.

40. In addition to incentives provided through the price differential, in-plan supplies may also carry the attraction for enterprises of firmer supply guarantees or supply priority, but this varies across fuels and over time. In previous years (e.g. 1988-89), coal was difficult to obtain in coal-importing regions, and "guaranteed supply" was attractive. During 1990-91, this

---

4/ In-plan energy supply quotas can be, and have been, increased for a small number of state-owned enterprises, but this is fairly rare, and requires special approvals (in the case of Hubei Province, the Provincial Planning Commission must approve). Some entirely new, large state-owned enterprises may also be granted some in-plan supplies when they begin operation.

has become less important, as it has been fairly easy to secure supplies in the major demand centers.

41. It is easiest to put pressure on enterprises in the case of electricity. For the enterprise, alternatives to supply by the state through the grid, such as autogeneration facilities, take time to develop and also may face other controls. Of course, a variety of out-of-plan power allocations, with higher prices, may be available through the grid, but government agencies can also constrain the availability of these to enterprises considered wasteful. In essence, much of the out-of-plan supply can also be controlled fairly easily, unlike the case of coal.

42. Petroleum products are controlled more tightly than coal, and generally they are in shorter supply. In addition to the in-plan and out-of-plan supplies routinely provided by state petroleum supply agencies, however, other supplies often can be obtained, although prices are particularly high.

Unit Energy Consumption Standards

43. In addition to the energy supply quota system, China also has developed a system of unit energy consumption standards that apply to most enterprises. Generally sanctioned as part of the 1986 Regulations, these standards fix an energy consumption ceiling per physical unit of production (e.g., ton or piece) of different commodities. These standards may also fix ceilings on unit consumption of individual fuels (e.g., electricity or petroleum products), in addition to total energy. Although these standards may be used as benchmarks for assessing overall energy supply quotas, they are different from the overall supply quota system described above.

44. Government officials in both Hubei Province and Shanghai Municipality described the complex and extensive systems of unit energy consumption standards which they have developed. While some type of system clearly exists in other areas, at least for the key energy-intensive commodities, the extent to which such extensive standards are being employed in all of China's provinces is unclear to the mission.

45. In Hubei and Shanghai, unit consumption standards are set, reported on, and reviewed for thousands of different industrial products. Authorities involved in energy conservation work consider these standards to be one of their most important policy tools. In Hubei, standards exist for 3760 items, the production of which accounts for over 70 percent of the province's industrial energy consumption. In Shanghai, some type of unit energy consumption standards exist for 95 percent of the commodities produced. In both Hubei and Shanghai, the local government (e.g., the PEC) first establishes overall guidelines for key commodities and industrial branches, based on any national-level ceiling or reference standards which may exist, and on existing data on the differences of advanced, average and poor enterprises. Local government industrial bureaus then review the actual cases of individual enterprises, and propose unit consumption standards on an enterprise-by-enterprise basis. Enterprise unit consumption standards are determined based on consideration of (a) enterprise statistics on energy use patterns over the last three years or so, (b) theoretical calculations of consumption norms for the specific processes and equipment in use, and/or (c) actual measured

tests of energy use.5/ Based on the industry bureau recommendations, PECs annually issue (or reissue) the unit standards, although most standards actually are changed only every three years or so.

46. If enterprises are discovered to be out of compliance with the standards, the PECs first issue a warning. In Shanghai, about 35 percent of the over 2000 enterprises subjected to on-site testing by the Municipality's Energy Conservation Technical Service Center during the last four years have been issued such warnings. If appropriate actions are not taken, enterprise managers may be criticized or the enterprises may be fined. These fines are different from, and additional to, any price increases or "above quota surcharges" that result from exceeding energy supply quotas. In Hubei, for example, enterprises are charged a fine by the Three Electricity Office (see para. 15) of some 3 *fen* per kilowatt-hour of consumption over and above unit consumption standards. In Shanghai, fines collected due to non-compliance with such standards have amounted to Y 500,000-1,000,000 in recent years. In both Shanghai and Hubei, this revenue is made available to enterprises (often the same enterprise which was fined) for energy-saving technical renovation projects.

Quotas and Standards within Enterprises

47. As stipulated in the 1986 Regulations, major energy consuming industrial enterprises are obligated to set up specialized energy management systems within their factories (para. 20). This includes the establishment and monitoring of additional standards and quotas at the workshop, office, and/or production line levels. Unit energy consumption quotas are determined and monitored for major energy-consuming pieces of equipment.

48. Monitoring of the adherence of workers to energy-related factory regulations, and energy conservation bonus and penalty systems for workers, are now standard features of the responsibility systems employed in major energy-consuming enterprises. The energy conservation aspects of the annual or biannual worker bonuses 6/ are usually based on the degree of adherence to unit energy consumption standards set for given workshops, production lines and/or specific pieces of equipment (depending upon what is technically simplest and most meaningful).

49. Although systems vary substantially from factory to factory, a typical system involves provision of an energy conservation bonus which is routinely provided to workers which adhere (or whose workshop adheres) to unit consumption standards, but denied to workers who fail to meet such standards. In one factory visited, for example, an "electricity conservation bonus", amounting to Y 5 per worker per month (or 10 percent of the overall average monthly bonus of Y 50 per worker per month) was provided to workers whose workshops met the average monthly unit electricity consumption standard. If the standard was not met, the Y 5 per month was withheld. If unit consumption was particularly excessive, it was understood that additional, stiff worker fines would be levied, but this was described as rare.

5/ The institutional network for conducting such tests is described in paras. 22-27.

6/ Annual bonuses, which are a key part of the worker responsibility systems put in place in an effort to improve worker incentives for improved productivity, are typically a major component of overall worker compensation in China.

50. Another sample system observed, which offers superior worker incentives to save energy, but is more complicated to administer, involves determination of bonuses and penalties that are tied more closely to variations in consumption. In this case, workers receive an energy conservation bonus amounting to 12 percent of the cost of any energy saved relative to the fixed workshop/production line/equipment unit consumption standard. However, workers must pay the full cost of any energy consumed over and above the level determined from the unit energy consumption standard. (This factory was paying relatively high, out-of-plan prices for all of its energy.) Annual bonuses were calculated based on the summation of month-by-month performance.

51. In addition, many factories also have a series of energy conservation regulations, and administer fines for transgression. Typically these involve rules for shutting off lights or fans, management of key energy-consuming equipment, etc.

Enterprise Performance Awards

52. The performance of enterprises in energy conservation work is one of the criteria considered in the current system of overall enterprise performance awards for special, first-class or second-class "progressive enterprises" (*xianjin qiye*). These awards are important for enterprises, not just for prestige, but also because they enable enterprises to obtain priority treatment in allocation of state investment funds or bank loans, to receive certain supplies on a priority basis, and to provide their workers with higher bonuses which may be expensed before calculating profits and taxes accruing to the state. There are both national and provincial/municipal-level awards. Award classifications include "special" level, first-class, and second class. At the national level, no enterprise has yet achieved the "special" level, and less than 10 percent have achieved first class status.

53. Criteria for the overall awards include areas such as economic efficiency, safety, raw material conservation, and enterprise management. Energy conservation criteria have been an aspect of the material conservation criteria for years. Recently, however, unit energy consumption performance has been given greater weight. The Sixth Meeting of the State Council's Energy Conservation Working Council (December 1990) announced that performance in energy conservation would now be an integral part of the determination of awards, and that enterprises which failed to meet energy consumption standards would not be given awards (or allowed to move up in award classification).

54. In addition to the overall awards, special enterprise energy conservation awards also are now issued at national and provincial/municipal levels, with similar classifications. Enterprises receiving these awards also receive some special favors, such as greater access to low-interest loans or rights to issue higher energy conservation bonuses. As seems to also be the case with the overall awards, most relatively large enterprises have some type of award, and hence much of the real differentiation between enterprises is in the type of classification. In Shanghai, for example, 453 enterprises have some level of energy conservation award, and together these enterprises account for about 80 percent of the municipality's industrial energy consumption. Of these, however, only 51 have a first-class national-level energy conservation award, while 203 have second-class national awards and 199 have only municipal-level awards.

Equipment Standards

55. A variety of standards have been adopted specifying minimum energy-efficiency levels for specific types of new equipment. Some type of energy efficiency guidelines are in place for nine different types of electrical appliances. The standards must be met by equipment producers and sellers. The mission was unable to fully review all of the details of the existing equipment standards systems and their implementation and enforcement. It is clear that some standards are more strictly enforced, as mandatory criteria that must (and generally are) met by all types of producers, while other standards are not as strictly enforced, and are used more as "reference standards."

56. Much of the focus of the current system is to ban particularly inefficient equipment from production. Since 1986, 14 lists have been published describing specific equipment models which are to be banned nationally from production. As of mid-1991, a total of 506 models of particularly energy inefficient equipment had been banned. A total of 713 items had been listed as "energy-saving models".

D. THE FUNDING OF ENERGY CONSERVATION INVESTMENTS

57. Since the early 1980s, the government has set aside specific funds for the support of energy conservation projects. Although a variety of more general funds also are available for projects which may have some content related to energy conservation, and the definition of what constitutes "energy conservation projects" can be disputed, these funds are allocated for project which have energy conservation as their primary objective. Although financing terms vary, much of the funding is provided at terms softer than prevailing market rates, with the support of state subsidies.

58. Conservation projects are financed with funds from the central government, local governments, and enterprises themselves. Typically, government financing amounts to about 70 percent of investment requirements, while enterprises provide about 30 percent of investment costs themselves, primarily from retained profits or depreciation funds. Government financing is now virtually entirely in the form of loans, as opposed to the grants which dominated in the past. As described previously, the SPC, SEC/SETO (at different times), and the Energy Conservation Company of the State Energy Investment Corporation are the chief agencies in charge of allocating the central government funds targeted for energy conservation investment. The local government Planning and Economic Commissions play these roles within local government. In the case of Shanghai, a special Energy Conservation Fund has also been established, using local funds. Government funds are disbursed primarily through the Banks; in the case of capital construction funds, the People's Construction Bank of China dominates, while the Industrial and Commercial Bank of China disburses most funds for technical renovation funds.7/ In addition, some funds may be disbursed through the Ministry of Finance, or in increasingly few cases, through line Ministries.

7/ For a brief description of the difference of these funds, see Footnote 1.

Financing Channels and Terms

59. Total investment in energy conservation projects over the ten year period of 1981-90 is estimated to have been about Y 27 billion, including all central government, local government and enterprise contributions. Of this about Y 10 billion was invested during the Sixth FYP (1981-85), and an estimated Y 17 billion was invested during the Seventh FYP (1986-90) 8/ These investments resulted in technical changes enabling energy consumption to be reduced by over 50 million TCE per year on a sustained basis (or, as commonly referred to in China, "energy savings capacity" of over 50 million TCE per year).

60. Although total investment increased in nominal terms between the two five-year plan periods, the share of central government compared to local government funding has declined sharply, as in most other sectors. In Hubei Province, central government investment funding for energy conservation declined from Y 490 million in the Sixth FYP to just Y 80 million during the Seventh FYP. Total energy conservation investment in the province increased, however.

61. The 1986 Regulations include a provision that, in energy-deficit areas or energy-intensive sectors, at least 20 percent of the depreciation funds retained by enterprises should be invested in energy saving technical renovations, on a regional or sector-wide basis (see paras. 27-28). This rule seems to be interpreted in various ways at local level. In some cases, the rule seems to have been interpreted as a general guideline to be applied at macro levels. The mission did observe cases, however, where specific enterprises reported that they had undertaken energy-saving investments in order to adhere to this requirement.

62. An example of the relative roles of different funding channels can be seen from the case of Shanghai Municipality in 1990. In that year, total investment funding provided by the government for energy conservation projects is estimated at about Y 130-140 million. (Enterprises provided additional funding, which is not included). Technical renovation projects accounted for a little under Y 100 million, for which central government funding contributed Y 15-20 million, local Banks contributed some Y 50 million, and the Municipality's Energy Conservation Fund provided about Y 25 million. Funding for capital construction projects was reported at just Y 30-40 million, although funding levels of Y 80-90 million were common in earlier years, when such capital was less scarce. The capital construction funds were provided by the SEIC's Energy Conservation Company, by the People's Construction Bank (from its own funds, at market interest rates), by the Municipality's Energy and Transportation Fund, and from a fund for substituting coal for fuel oil.

63. Financing terms have varied over the years, and depend upon the funding channel. The length of loan periods varies substantially. Loans provided by the Energy Conservation Company of the SEIC are virtually all for periods of 5-15 years. Although few no-interest loans have been available, interest rates also have varied. During the Sixth FYP, the regular interest rates offered by the Banks were low—generally a little over 4 percent per annum. The interest rates of most energy conservation loans (funded either as capital construction or technical renovation projects) was subsidized by some 50 percent, so that interest rates were 2.0-2.5 percent. During the latter 1980s, however, normal interest rates climbed to 8-11 percent per

---

8/ Both figures are in current prices.

annum, and subsidies were reduced. Interest rate subsidies for many technical renovation projects were removed. More recently, subsidies have been increased again.

64. During the Fall of 1991, conventional Bank loans were most often quoted at 7.8 percent per annum, but Bank interest rate reductions of 1-2 percent for energy conservation technical renovation projects were reported in some cases. Most capital construction loans provided through the SEIC's Energy Conservation Company carried a 30 percent discount, and hence an interest rate of about 5.5 percent. The Beijing Municipality Planning Commission was providing capital construction loans for energy conservation at rates of 2-3 percent per annum. In both Hubei and Shanghai, local governments were providing some rate subsidies for conservation projects; in Shanghai, the Municipality was providing an interest rate subsidy for at least some technical renovation projects of about 50 percent.

65. Table 1 provides an example of the funding package for a major energy conservation project which may be typical of more complex project today. The project involves the construction of a combined heat and power plant, and the provision of a district steam supply system to a series of factories that have existing small-scale boilers. As such, environmental protection is one of the project's major goals.

Table 1: AN EXAMPLE OF AN ENERGY CONSERVATION PROJECT FINANCING PACKAGE
(Total Investment: Y 53 million)

Funding source	Share of investment (%)	Annual interest rate (%)
SEIC Energy Conservation Co.	42	5.5
Industrial and Commercial Bank	23	7.8
An investment trust company	11	9.2
Municipal Electric Power Co.	9	/a
Municipal Environmental Protection Agency	6	/a
Enterprises' contribution	9	/a

/a Investment provided for an equity share.

Appraisal Criteria for Conservation Projects

66. In reviewing prospective energy conservation investments, Chinese planners put much of their focus on the sustained energy savings, in TCE, which will result per unit of gross investment, in current yuan. This "investment per TCE of energy-saving capacity" can then be conveniently compared to the alternative investment cost of delivering incremental energy supply. Implicitly, the dominance of this indicator in the investment appraisal process also means that emphasis tends to be given to projects which physically reduce energy consumption for a given output level, as opposed to "broader" types of energy conservation projects, which

might increase product output or quality (and hence value) without corresponding increases in energy use.

67. In its review of potential projects (for which the number of applications far exceeds financing capabilities), the Energy Conservation Company of the SEIC puts primary emphasis on the investment cost per TCE saved. Secondly, the Company considers the loan period which will be required, generally favoring shorter loan periods. The criteria which ranks third is environmental and social benefits. Economic benefits are considered as a final criteria, but receive little emphasis. The Company's policy is intended to directly follow the government's objectives for use of the allocated funds, that is, to promote energy savings first, and social and environmental goals second. It is felt that energy conservation projects with good economic returns may best be financed through other channels or with the own funds of enterprises. (This overall policy also appears to prevail within local government agencies as well.)

68. About 70 percent of the Energy Conservation Company's funding is used for "conventional" projects. These are generic projects where the technology is proven, and experience has demonstrated sound energy conservation and social/environmental benefits. In recent years, about 10 percent has been used for pilot or demonstration projects. The final 20 percent is used for projects which are in between these two; that is, to establish additional experience with a type of technology that has been successfully tried out in just a few cases.