The Market for Energy in China

by
Shu-Kam Lee

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Abstract

Since 1979, China embarked on an economic reform to modernize the country. The reform was so successful that China was able to grow by an impressive rate of 9 percent per annum between 1979 and 1997. The rapid development of the economy leads to a drastic increase in demand for energy. Since China has the largest population in the world, its energy demand is nothing but huge. Each year, for example, China needs to install as much as 10,000 MW of new electricity generation capacity, which equals the current capacity of Netherlands. This increase in demand for energy, which is likely to continue, will have implications for global energy markets, the world price of energy and for the global environment as emissions of greenhouse gases grow rapidly.

Against this background, there is an urgent need for the country to better manage the energy sector so that the market can function in an orderly manner. To tackle this issue, I single out three important energy problems to study. First, I will examine the current situation of the energy imbalance in China. Second, I will forecast how rapid the energy demand will grow in future so that the deficit between the demand and domestic supply can be identified. Lastly, I will discuss some methods that can be used to manage the demand.

My finding shows that energy-capital and energy-material inputs are complementary, whereas the relationship of energy and labour is insignificant. In addition, the simulation exercises also reveals that a high energy pricing policy might not be effective in mitigating the demand and in encouraging firms to employ labour intensive techniques. Also, rising energy prices may bring spiral inflation and deterioration in the balance of payments and foreign resources. Therefore, government should act cautiously when increasing energy prices.

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" The LORD give wisdom, and from his mouth come knowledge and understanding." (Proverbs 2:6).

Chapter 1: Introduction

1.1 Background and Aims

Since the launch of economic reforms in 1979, China has successfully turned itself into one of the fastest growing economies in the world. The rapid economic expansion in turn has given rise to a steady rise in energy consumption[1]. The rise of the energy consumption after the reform was so drastic that China has surpassed the Russian Federation since 1994 and become the world's second largest consumer of energy after the United States (Sinton, 1996). In 1995, China produced 5,847.81 billion yuan of GDP and consumed 1,311.76 million tons of standard coal equivalent (SCE) [2] of energy.[3]

The importance of the energy sector is not limited only to the domestic economy. As observed by Wu and Li (1995), China has to rely increasingly on the external energy market for meeting its rapidly growing demand. As a result, China's energy imports soared 20-fold from only 2.61 million ton SCE in 1980 to 54.56 in 1995, whereas energy exports increase almost twofold from only 30.58 million ton SCE to 67.76. The rising gap between demand and indigenous supply inevitably needs to be met by increasingly greater amounts of energy imports. As

[1] Note that the largest user of energy is industry. It accounted for about three-quarters of both total commercial energy and coal use in 1990. Whereas, the typical household consumes very little because most people are living in rural areas which are very poor. Therefore, the residential sector consumes only 12% of the total consumption in 1995.
[2] One standard coal equivalent (SCE) is 7,000 kilo-calories per kilogram.
[3] China Statistical Year Book (1996).

China's magnitude of energy trade (both exports and imports) is not small, the gap will invariably affect world energy trade and prices. Against such a backdrop, it is therefore essential to study China's energy development.

In spite of the fact that energy is fundamental and essential to the growth of the Chinese economy, not much research work have been devoted to the topic of energy imbalance in China. Among the existing studies[4], most are mainly qualitative analyses. By contrast, I attempt to employ some quantitative techniques to analyse China's energy consumption and pricing policies. One aim is to offer guidance towards formulating policy.

1.2 Outline of the Thesis

In order to achieve the above objectives, the thesis will be divided into four parts. Part A employs a descriptive approach to assesses China's ability to manage the energy sector. (Chapter 2). Part B and Part C are quantitative studies of energy issues. Part B predicts the demand for energy utilising a demand side approach (Chapter 3 to 4). Part C adopts a supply side approach to evaluate the role of government energy pricing policy in managing the energy industry (Chapter 5 to 7). Part D is a summary of the findings in the previous sections (Chapter 8).

[4] Such as Wu and Li (1995), Johnson (1995), China Statistical Information and Consultancy Service Centre (1990), Sinton and Levine (1994), Kambarra (1992), Nakajima (1992).

Before discussing the outline of the thesis, it is necessary to compare the demand side and supply side approaches. In the demand side set-up, the firm is treated simply as a consumer of various inputs. The demand equation is often specified by past experience and estimated by typical econometric techniques, such as general to specific approach, cointegration and an error correction model. Under this approach, specification and variables used in the model are freely chosen, and then tested down to the final preferred model. As this approach simply specifies the relationship between input demands and other exogenous variables, which normally includes input prices, output level and structural variables etc., the relevant price elasticities (i.e. price/cross price elasticities) are easily computed. For example, the estimated coefficients of the price variables in a double log-linear demand function are price elasticities, which can also be obtained from multiplying the ratio of quantity demanded to price with the price coefficients of a linear demand equation. Based on the estimated coefficients, one can forecast the future energy demand.

However, there are a number of problems associated with this approach. For instance, one may question critically which variables should be included in the demand equation. Furthermore, it is likely that too many explanatory variables would be introduced which gives rise to the so-called "degrees of freedom lost" problem. This problem is particularly serious when the sample size is relatively small.

In the second approach, the firm is treated as a supplier of a final good or service, so this kind of estimation is commonly referred to as the "supply side approach". The starting point is to specify an indirect profit function (cost function) which has a number of well-known production features.[5] After obtaining this function, one can use Hotelling's Lemma (Shephard's Lemma) to derive the output supply and input demand equations (conditional input demand equations), and then estimate them using sample data. The explanatory variables used in this model are therefore based on optimising theories and normally restricted to prices of all inputs and outputs for cost minimisation (or instead, price of output and input for profit maximisation). One obvious drawback of this approach is that it may exclude some variables that have important bearing on the energy demand. Typical examples are the structure of the economy - an economy that has a high composition of heavy manufacturing, is likely to consume more energy than the one with a small share of such industry. In addition, the price elasticities derived from this approach are more complicated than those obtained under the "demand side approach". Besides, different functional forms (such as translog and quadratic) and assumptions of firm behaviour (either profit or cost equation) might result in different input demand functions and price elasticity formulae. Hence, the first approach is much easier and more flexible in term of specification of the input demand functions and calculation of the elasticities, while the second approach has a more solid theoretical basis.

Beyond this, there is one more important difference between these two approaches. The first approach usually requires national time series data. On the

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5 For example, an equi-proportionate change in output prices and all input prices does not alter the input mix or encourage the firm to produce more output i.e. the producer does not suffer from money illusion. In addition, this theory also requires that the derivative of the profit function with respect to the output and input price are homogenous of degree zero in output and input price. We will discuss the properties in later chapters.

other hand, it is more appropriate to use a pooled firm data set for the second approach, since it incorporates the rational choices of inputs by firm. Usually, these kinds of data are available only at the micro-level only. As I am able to obtain a set of surveys of firm data, the supply side approach becomes feasible as well. Since this data set was administrated by the State Statistical Bureau of China in 1989, it is believed that the statistics are relatively accurate. Nonetheless, it should be mentioned that this survey data set does not include energy consumption of each firm, and so it cannot be used in estimating energy demand in the first approach. Instead, I employ the national time series data from 1952 to 1994 to estimate energy demand. On the contrary, the second approach can be employed with survey data because it only needs the data 'share of the energy expenditure in profit', which is available in the firm data set. Unfortunately, the observation period of this data set is only 1985-88 and so the energy deficit period was not covered. Consequently, this problem cannot be taken into account in this data set. However, the empirical findings from the second approach still can be projected to conduct energy policy analysis on energy insufficient problems. All in all, these two approaches have their own relative strong points and so, both of them will be used.

1.2.1) Part A: Descriptive Approach to Energy Imbalance in China

In Chapter Two, I consider the problem of China's energy imbalance problem. In the first part, I discuss what policies the government has initiated to overcome this problem in the past decade. Next, I try to find out the problems that China still needs to confront in the future and to evaluate the possible remedial policies for the energy deficit. This chapter contains a general discussion on the demand and supply of energy.

1.2.2) Part B: Demand Side Approach to the Prediction of Energy Insufficiency

Chapters Three and Four assess the severity of the energy imbalance.[6] To do this, it is necessary to specify an energy demand model. Since energy is one of the production factors, an energy demand function is commonly treated as one of the input demand functions. The important relationships are those between the demand for energy and prices of energy and other factors.

In Chapter Three, I use the vector error correction (VEC) model to forecast China's future energy demand. Although there are other studies that have forecast future demand for energy, they are flawed by the problem of spurious regressions, which occurs when time-trend-driving variables may appear to be correlated in finite sample regression, even though there is no true relationship among them.

[6] Due to the availability of the data, it has not been easy to estimate and forecast China's energy supply until now.

Moreover, to perform forecasting, the traditional approach requires us to predetermine the future values of the exogenous variables, which means that forecast values are subject to the subjective assumptions about the future values of the explanatory variables. However, VEC model can overcome these problems. Hence, I employ this technique to analyse the energy consumption behaviour and generate its ex-ante forecasts to the year 2000.

In Chapter Four, I model the demand for coal. In contrast to developed countries, coal is the major energy source of China.[7] My purpose is to identify the major factors that determine coal demand. To achieve this, I apply the cointegration and error-correction models to model Chinese coal consumption data. Since the error correction approach is a single regression which is quite different from the vector error correction approach employed in Chapter Three, it requires us to make some assumptions about the future values of the exogenous variables. Because of these particular characteristics, it is possible for us to assess the impacts of how the changes in exogenous variables will affect the energy

7 China's energy consumption depends on energy resource availability and production in China. The production of high quality energy, such as petroleum, natural gas and electricity, still cannot meet the rapidly increasing demand. Although crude oil, natural gas and hydropower contribute important shares of current energy components, coal still maintains the dominant position in primary energy supply and consumption of China. In the 1950s, coal composed about 95% of commercial primary energy. Along with the exploration of big oil fields like Daqing and Shengli from the beginning of 1960s, the share of oil and gas have increased a lot, achieving around 28% in the middle of 1970s combined with hydropower. While from 1980, the development of oil and natural gas became more and more difficult, coal has increased its share in the energy supply since then. The annual growth rate of coal consumption was 5.6% in 1980s, higher than that of primary energy consumption. Coal consumption was 1140 million tons in 1995, accounting for 74.6% of the total energy consumption. Coal is not only the dominant source of energy, but also is an important raw material of the chemical industry.

imbalance. The availability of this model would allow us to evaluate the effectiveness of controlling those variables in managing the coal demand in China.

1.2.3) Part C: Supply Side Approach to the Evaluation of Energy Pricing Policy

The Forecasts by econometric techniques from Chapters Three and Four can verify the qualitative analysis in Chapter Two whether China will suffer from energy shortfall in the next century. If so, it is necessary to implement energy policies to alleviate this problem. Chapter Two has evaluated the effectiveness of such policies. However, the analyses are mainly qualitative approaches and the findings may be different if the studies are based on quantitative techniques. On the other hand, increasing energy prices is currently the major instrument in China to mitigate demand. However, its impact on the economy and energy consumption is controversial.

Therefore, in the following chapters, I evaluate the energy pricing policy in managing the energy sector by the "supply side approach". Chapters Five, Six and Seven regard the estimation of input demand functions and of own price and cross price elasticities, aiming to investigate the complementarity/ substitutability among energy and other input factors such as capital and labour, and hence evaluate whether a high-energy pricing policy can solve energy insufficiency. The findings are of strong interest to the Chinese energy sector. It is because the use of a high price policy may lead to different possible outcomes. For instance, an increase in energy price could result in declines in capital formulation and perhaps in lowering labour productivity growth. The economy may shrink as a result. In the alternative situation, the high pricing regime could encourage more rapid capital formation and so achieve the goal of energy conservation with more desirable and productive outcomes. Therefore, the effects of rising energy prices on energy saving and output growth are ambiguous. This ambiguity is hinged on the substitution/complementary relationship among energy and other (non-energy)-input factors. The evaluation of the effects of a higher pricing policy will provide an important lesson, especially when such policy is implemented to narrow the future energy insufficiency.

The input demand functions and relevant elasticities can be derived from traditional translog profit models. However, the traditional methods ignore the effect of rationing on such derivations. As rationing occurs frequently in Chinese enterprises, applying rationing behaviour to Chinese data may therefore be strongly desirable. In light of this, I modify the traditional method and derive the price elasticities by introducing a virtual pricing approach. During the observation period (1985-88), energy deficit has not emerged as an important constraint. However, most Chinese firms were likely suffered from insufficient material inputs over this period. Therefore, in order to take this problem into account, material inputs are chosen ex ante as rationed input whereas energy is treated as a variable factor without rationing. Nevertheless, for the period after 1992, energy has changed to become a rationed input as energy deficit has become serious. Unfortunately, I cannot find a data set that has 1990s information and hence cannot choose energy as a rationing constraint in my model. Nevertheless, the exercise conducted in this thesis illustrates how rationing can be modelled and such useful information as price elasticities be derived. More importantly, the results also can be used to project energy policy analysis in later period when energy imbalance occurs.

In Chapter Five, I begin by reviewing the literature on the controversy between capital and energy. I then explain why rationing should also be an important factor. After that, I review and compare different methods that can be used to derive input demand functions. From the review, I argue why the dual approach and translog profit function is suitable for this study. In this chapter, the advantages and drawbacks of this approach will be presented in detail.

In Chapter Six, I explain how the elasticites are derived from a translog profit function. In the first section, the elasticities are derived in the traditional way which is under the assumption that there is no rationing in the economy. As rationing is currently occurring in China, I incorporate the rationing behaviour in deriving the elasticities. Following this argument, I explain and compare how the two approaches i.e. the auxiliary constraint and the virtual pricing approaches-can deal with the rationing. After this comparison, I conclude that the virtual pricing approach is more appropriate to derive the elasticities under rationing. The derivation of the elasticities is presented in the last section.

Chapter Seven adopts the translog profit function to the firm data set to derive relevant price elasticities. At the beginning, I introduce the survey data and explain how the translog profit function can be formulated in my energy model. After that, I discuss the adopted econometric technique. The estimates of the translog profit equation then are substituted into the formulae derived in Chapter

Six so as to obtain the elasticities with rationing and without rationing. From the signs of the elasticities, I can examine the relationship between energy and other inputs and hence evaluate the effects of raising the energy price policy on the economy. With the figures of energy forecasts obtained in Chapter Two and Three, different policy options are evaluated and their findings provide more understandings on the effect of a high price policy towards managing energy insufficiency.

1.2.4) Part D: Conclusion

Chapter Eight summarises this study under the three aspects which are mentioned above, i.e., to assess the ability to manage the energy sector, to predict the size of the imbalance between supply and demand, and to evaluate the role of government's energy pricing policies in China.

Chapter 2: An Overview of Energy Market in China[1]

2.1 Introduction

After many years of hard effort to manage the rapid growth of energy demand, energy remains a major input constraint in China. The most severe imbalance began to occur in some sectors after the early 90s resulting in considerable disruption to the economy as factories in many cities had to be closed several days a week in order to mitigate the electricity shortfall. At present, although the imbalance is apparently less severe than several years ago, it is far too early to conclude that the problem is totally solved as the economy is expected to continue to grow at a relentless rate into the foreseeable future. Against this backdrop, the problem of energy constraint will inevitably remain a dominating issue in the formulation of the energy policy. In view of this, this chapter will attempt to examine this particular issue. First, in the next section, I will evaluate the experience of the country in handling this problem. Despite some important achievements towards overcoming the energy imbalance, China still needs to face a number of formidable problems in the years to come. In section three, therefore, I will attempt to point out some of the important issues that remain to be solved. Based on this discussion, I attempt in section four to propose some policy prescriptions for managing the problems. The final section draws out the major points of this chapter.

[1] This chapter is to a large extent based on the paper in Energy Policy (Chan and Lee, forthcoming)

In order to better understand the major issues facing China, it is beneficial to start by examining the future energy balance of the country. As China approaches the end of this century, the planned output targets laid down by the government for coal, oil, gas, hydro-electricity and nuclear energy in the year 2000 are summarised in Table 2.1. Aggregating them into a common unit, namely million tons of standard coal equivalent (Mtce, hereafter), implies that the Chinese energy producers are planning to supply a total of 1,380 Mtce by the year 2000. According to one official estimate, China will need around 1,500 Mtce at the same year. Consequently, a deficit of 120 Mtce is expected to occur as the country approaches the end of this century. Among all the major fuels, the shortfall of oil will be the most severe. In order to close this gap, 43 Mtce of oil is needed to be imported. At the current international price of US$20 per barrel, this would amount to US$4.2 billion. In order to secure external supply, the government plans to procure about 22 Mtce of oil through bilateral agreements with such countries as Kazakhtsan and Turkmenistan. The remaining shortfall of 20 Mtce to 25 Mtce will be made up by conventional imports.[2] In 1996, China recorded a trade surplus of US$ 16.6 billion. Therefore, the deficit of energy balance will be kept at a manageable level over the next few years.

[2] Source: South China Morning Post, 6th April 1997, Money Section, p.2.

Table 2.1: China's energy supply and demand in the year 2000 and 2010

	Energy supply in the year 2000 (Mtce)[1]	Energy demand in the year 2000 (Mtce)[2]	Energy supply in the year 2010 (Mtce)	Energy demand in the year 2010 (Mtce)
Coal	1,000	1,064	1,285[3]	1,373
Oil	241	284	276[4]	358
Gas	33	40	93[5]	80
Hydro-electricity	100	97	142[6]	143
Nuclear electricity	4	-	30[7]	-
Others		7		47
Total	1,377	1,495		2,001

Sources: 1) *People's Daily*, 20th March 1996 and Yan (1994), p.11-12. 2) The demand estimates for both 2000 and 2010 are from Zhou Fengqui (1996). 3) Yan (1994), p. 66. 4) Zhou Yongkang (1996). 5) Same as 4. 6) Wu and Wang (1995). 7) Same as 4.

2.2 The experience of mitigating the Energy Constraint

To maintain China's energy imbalance at a manageable level is by no means an easy task, as the country's GDP experiences a phenomenal growth rate of 9.6 percent between the start of reform in 1979 and 1995. Such growth rate puts enormous pressure on energy supply. In order to overcome the energy insufficiency, the Chinese government has initiated a number of policies, some of which have been quite successful in narrowing down the deficit.

2.2.1) The Rapid Rise of Small Coal Mines

One of the key energy policies that the government has undertaken after the reform is to encourage the local initiative to expand coal supply. The government adopts this policy because the mine ownership is very diverse in China. In 1979, 55 per cent of output came from the state-owned coal mines. A further 31 per cent of production came from state mines owned locally at provincial, prefectural and county levels. The remaining 14 per cent of output was obtained from village-owned coal mines. In comparison, the national coal mines tend to be larger and more highly mechanised than small rural coal mines in the villages. However, the rural mines grew at a spectacular rate after the reform. In 1993, for example, village coal mines account for 35 percent of the total coal output, while the national and local state own mines produce around 40 and 25 percent respectively. To sum up, the emergence of the small coal mines enables the country to achieve the goal of producing 1.4 million tons of raw coal by the year 2000, which many considered unattainable when the government first announced this target in the 1980s.

The development of small coal mines helps not only to increase the supply of coal, but also alleviates the transport bottleneck which caused severe energy constraint in the late 1980s. The country is vulnerable to such bottlenecks because the distribution of coal deposits is geographically very unequal in China; nearly 80 percent of them are concentrated in three provinces: Shanxi, Shaanxi and Inner Mongolia, which locate in the north and north-west of the country. However, the major consuming centres are in the east and south. As a result, large amount of coals have to be transported long distances before reaching their consumers. This situation has resulted in a significant strain on the coal-carrying capacity of the rail system. In the worst years, many businesses around the country were idle due to lack of electricity, while large piles of coal sat unused outside the mines. Transport bottlenecks have been alleviated in part by the proliferation of small coal mines which scatter more evenly around the country. As a result, the largest three coal abundant provinces accounted only 34.3 percent of total coal output in 1993. The rise of local coal suppliers therefore significantly reduces the demand for coal from large coal mines.

2.2.2) Relieving the Capacity Constraint

The second major factor which has contributed significantly to narrowing down the energy imbalance is the rapid build up of electricity generation capacity. This relieves considerably the energy constraint because China has not only experienced deficit of energy inputs, but also insufficiency of electricity generation capacity. In order to alleviate this gap, the government sets the development of power industry as a first priority. As a result of the rapid development of small coal mines, this allows the government to shift greater proportions of investment from the coal to power industry. In 1995, for example, almost 60 percent of the government's investment in the energy industry went to the power industry, while only 13.6 percent was given to the coal extraction industry (State Statistical Bureau, 1996). In comparison, the power and coal extraction industries absorbed 29.8 and 48.3 percents of all the energy investment in 1985, respectively. The commitment to the power industry is undoubtedly strong. Currently, the government aims to upgrade the power system. For example, the government plans to increase power capacity to 290 Gigawatt (GW) by the year 2000. To achieve this target, 16 GW of new capacity is expected to be added each year in the present ninth Five-year Plan (1996-2000). In terms of growth rate, the power industry will rise by 7 percent annually; this is almost twice the growth rate of the entire energy sector. Equally important for handling the energy imbalance, the government plans to join up the existing six cross-provincial transmission grids into a single system so that surplus electricity can be transferred readily to deficit areas. Among the first to be connected are the northern and northeast regional grids. By the year 2003, when the first part of the Three Gorges hydroelectricity project in central China will be completed, the transmission grids will allow 100 billion Kwh of electricity be transmitted each year from the Three Gorges to the consuming centres in the eastern provinces along the coast. It is planned that a national grid will be completely formed around 2020.[3]

2.2.3) Getting Prices Right

Price changes have been one of the most significant results of the reform. In the centrally planning system before the reform, the prices of fuel were treated as an accounting unit with no direct bearing to the cost of providing the resources. Such practices have given rise to a great deal of problems after the reform. First, since the price signals are distorted, consumers are unlikely to make correct decisions. This is

[3] Source: *Tai Kung Pao*, 4th April 1997, p.C7.

particularly worse when the prices of energy are significantly fixed below their opportunity costs.

In view of this, the authority began to rectify energy prices. For example, a two tiered system was introduced in 1985 under which oil producers were allowed to sell their above quota output at a price higher than the state-administered price. As shown in Table 2.2, the above quota price of crude oil remained substantially higher than the government-administered price, although the gap started to narrow in the early 1990s. Later on, the government took another major reform step by introducing a market price to the second tier in 1993. Although the two-tiered price structure remains intact, the market price has not since departed significantly from the international price.

Table 2.2: The domestic oil price structure of China.

	Plan			Market
	Low		High	
1985	100		555	
1990	167		555	
1991	201		589	
1992	201		589	
1993	205		535	1000
1994		700		1232
1995		700		1250

Source: Bi (1994) and Chao (1996).

The long-term objective of the government is to raise planned prices to international market levels before the end of the century. In moving towards this goal, the price for the first tier, which is normally sold to government-subsidised sectors, was raised to between 880 yuan and 964 yuan per ton in early 1997.[4] The second-tier crude, which is sold at market prices, remains at an average of 1,200 yuan per ton. Following this, the authority plans to introduce an additional price increase of 200 yuan per ton to the first-tier crude oil in 1998, effectively ending the two-tiered system. Since the first tier crude oil represents about 80% of onshore production, a great majority of oil consumers will increasingly need to face international prices. The determination to rectify the previous pricing policy will minimise the inefficiency of consumption caused by the arbitrarily held down energy prices.

In addition to causing consumption inefficiency, the adverse impacts of arbitrarily held down prices are particularly notable for the national coal mines. Table 2.3 shows the amount of economic losses that state coal mines suffered over the last eight years. The implementation of the price increase has reversed the trend of the losses suffered by the coal industry. From a loss of 6.2 billion yuans in 1991, the loss in profit of the national coal mines fell to 1.0 billion yuan in 1995.

Table 2.3 Economic losses (billion yuans) of state coal mines in China.

Year	1988	1989	1990	1991	1992	1993	1994	1995
Loss	-1.8	-3.7	-6.1	-6.2	-5.3	-3.3	-2.0	-1.0

Sources: *China's Statistical Yearbook* and *China's Economic Yearbook*, various issues.

[4] Source: *Asian Wall Street Journal*, 2nd April, 1997, p. 25.

2.2.4) Improving energy consumption efficiency

Another major factor which helps reduce the energy imbalance is the improvement in energy consumption efficiency. In contrast to the pre-reform period during which the energy intensity (energy consumed per unit of output produced) climbed steadily, it declined consistently after the reform, which enables the country to save a substantial amount of energy. For example, during the recently elapsed Eighth Five Year Plan (1991-1995), the economy grew at an annual rate of 12 percent, while energy consumption increased by a mere 5.5 percent. As a result, the demand elasticity ratio fell to as low as 0.46 (5.5%/12%) in these five years. In comparison with the elasticity ratio of the Fifth Five-Year Plan (1976-1980), which equals 1.0, it is clear that the energy intensity has been greatly improved after the reform.

This remarkable performance can be attributed to the following changes. First, under the reform, firms are given greater incentives to be more cost sensitive. For example, they are allowed to retain part of their profits after the reform. Also, firms' investment has to derive from bank borrowing instead of government allocations. These types of new policies naturally lead most firms to place a greater emphasis on cutting cost which includes energy expense. Second, the emergence of township enterprises (TVP) also helps reduce the demand for energy. One of the most spectacular changes after the reform is the rapid growth of the non-state sector. Between 1984 and 1994, for example, the growth of industrial output in non-state enterprises was double that of state-owned enterprises. In the non-state sector, about

4/5 of the output was produced by TVP. More important, not only have TVP grown faster than the state-owned enterprises, they are also more efficient; the total factor productivity for SOEs is estimated to be only one third to one half the corresponding rate for non-state enterprises (Broadman, 1995, p.13). As a result, TVP represents a major source of energy saving. Third, the introduction of energy price reform also plays a significant part in increasing energy efficiency. Subsequent to the energy price rise, the amount spent on energy inputs has become more important. As Chinese firms have become more market oriented at the same time, price reform would help stimulate the consumers to be more efficient in using energy.

2.3 Remaining Problems Ahead

2.3.1) The Growing Oil Deficit

The energy balance looks much less optimistic when the forecast is extended to the next decade. Several problems deserve policy-makers' attention. In particular, the total energy supply is expected to grow at a rate significantly smaller than demand. This is particularly noticeable in the oil sector because the forecast for oil supply in 2010 is 276 Mtce which is nine percent more than that of 2000. At the same time, however, the demand for oil will rise to 358 Mtce, exceeding the supply by 30 percent. This will imply that China will need approximately 82 Mtce of