

China's Insatiable Energy Needs



中國能原市場

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Table of Contents

Preface	4
Background To China's Energy Picture	7
An Examination of China's Economy	16
China's Population	19
The Size Of China's Economy	23
The State Of China's Economy	25
Regional Differences In China's Economy	27
Background On The World's Largest City	28
Role Of Greater China/Overseas Chinese	30
The Impact Of China's Economic Investments	32
China's Economic Achilles Heels	34
State-Owned Enterprises	35
Chinese Morality	37
Inflation	40
How Fast Could China's Economy Expand?	41
The Successful Ingredients For a Country To Grow	46
China's Energy Supply	48
China's Coal And The Environment	49
Alternatives To Coal: China's Other Energy Options	53
China's Sleeping Tiger: Natural Gas	55
China's Oil Resources	58
China's Onshore Oil	59
China's Offshore Oil And Gas	62
China's Expansion Into International E&P	64

Projecting China's Future Energy Needs	66
Is The Past A Clue To The Future?	68
The Conventional Wisdom Growth Models	71
The Platform Economies: Hong Kong, Singapore and Taiwan	74
The Impact Of China Changing Its Fuel Mix	75
What The World And China Need To Do Next	81
Building An Energy Bridge	87
Appendix	90

Preface

I began analyzing detailed data on oil and gas demand in the late 1980s as it became more apparent that the Great Oil Field Depression would never end until demand for oil and gas throughout the world finally ate through the massive overhang of supply. Over the ensuing years, I have been fascinated in watching the rapid growth in the demand for hydrocarbons in almost every part of the world, but in particular the soaring demand for petroleum products from the rapidly expanding Asian economies.

As I continued to peruse various reports and analyses about the demand for oil and gas, I began to realize how out of touch the views of most energy economists were on the rate of increase in demand for oil and gas over the past decade. For instance, in 1990 the U.S. Department of Energy predicted the world's oil demand would hit 70 million barrels a day in 2010. It turned out that world oil demand reached this level in 1995! In its most recent forecast for 2010, the U.S. Department of Energy estimated oil demand to grow by over 25 million barrels per day from their forecast prepared just seven years ago. At the heart of this rapid growth demand is the almost insatiable needs of East Asia and particularly China.

China has always been an energy enigma to me. The country is a major producer of oil yet hardly uses any natural gas. China used to be a major oil exporter but now consumes more than it produces. While its total volume of oil consumption is high, its per capita consumption is one of the lowest in the world: one barrel per person per year. While China's growth in oil demand has rapidly climbed, its per capita consumption has remained extremely low by almost any comparative standard.

Two years ago, I began using China's "almost one barrel per person oil consumption" as a classic example of why worldwide oil demand would continue to grow. I also occasionally demonstrated how much added oil the world would need to produce if China ever reached a per capita consumption equal that of a country like Mexico or even Taiwan.

Since I had never traveled to China, I did not have a feel for how long it would take China to reach such levels, nor did I really appreciate whether it was even possible for China to hit the levels of oil demand seen in Mexico and Taiwan. Critics of my seemingly overly optimistic view of demand for oil would often tell me about the many barriers that would always limit a country

like China from ever reaching “normal developing country demand levels”. They cited factors like the number of Chinese peasants, the lack of roads, and the inherent inefficiencies of the entire Chinese system as reasons why China’s future growth in oil demand would be relatively slow, and why its per capita consumption would remain very low.

Finally, I decided to visit China in order to draw my own conclusions. In April 1997, the Harvard Business School Alumni Association held its Global Alumni Conference in Hong Kong. Since I had been one of the original sponsors of the concept of a worldwide HBS Global Alumni program, I made sure my schedule allowed me to attend the Conference. The program’s content focused on Greater China: A Myth or Reality, which proved to be an excellent workshop on how significant China’s changing economy really was. But more importantly, I used this trip as an excuse to visit one of the few countries in the world that I had never traveled to—China.

After spending four days in Hong Kong where we listened to several excellent talks about the prospects for Greater China, my wife and I then spent another 10 days visiting four cities in China. While in Beijing, I was fortunate to visit with several senior planning officials in the Chinese government and senior executives at both CNPC and China’s Offshore Oil Corporation, (“CNOOC”). But, we were primarily tourists during our stay and from early morning to late at night, we walked, rode buses and observed one of the most fascinating countries we had ever visited. Prior to our visit, I had assembled a reading collection of almost every report published on China’s oil and gas industry, along with material on the economic changes underway throughout China. By the end of this two-week trip, I had attempted to digest each report.

The more I read and the more we saw and heard, the more convinced I became that none of the published studies even came close to understanding how dramatic China’s future energy needs would be, nor did my simple per capita comparative tabulations tell the real story.

Upon my return to Houston, I intended to do a simple interoffice memo highlighting my key conclusions on China’s future energy needs. But, as I began to plow through all the data I collected and started thinking through what it all probably means for the world, I decided to expand the scope of the paper. China’s urgent need for vast amounts of additional energy supply needs to be better understood since they could easily influence the major geopolitical

issues of the early part of the next century. At the least, these energy needs will clearly be the dominant factor impacting the oil and gas industry for the next several decades.

In addition to China's struggle to keep its daily supply of oil and gas ahead of its surging demand is an environmental battle of epochal proportions since the country is attempting to wean itself from coal, which already threatens to poison China's air, water and crops.

After preparing this report, I am convinced that the story of how China satisfies its future energy needs will be one of the most fascinating energy issues of the next 10 to 20 years. At the end of the day, China must succeed because there are over 1.2 billion people who strive to live the type of life that Americans have grown to love for so long. The Chinese are simply too ambitious and hardworking to be denied this type of lifestyle. However, figuring out how China makes this transition will not be an easy task. Moreover, the entire world has an important stake in helping to assure that China succeeds. Without ample energy, all of China's well intentioned dreams of joining the other leading countries in the 21st Century will not occur.

***Background To
China's Energy Picture***

Introduction

The world will be profoundly affected by China's economic revolution, which could be of historic proportions. The parallels are perhaps the Industrial Revolution in England, America's experience in the early part of this century and the phases of economic expansion in Japan, South Korea, Hong Kong and Taiwan.

Were it not for China's massive population base and its geographical span (compounded by the tiny size of its economy today), the impact of this coming economic revolution would not be so material to the rest of the world. However, with China representing over one-fifth of the world's population, and since the Chinese occupy the second largest geographical land mass in the world, its economic changes will directly or indirectly impact almost all other parts of the world in a profound way.

Furthermore, these changes could have the greatest impact on our energy resources since the introduction of the automobile. The continuation of the high total energy demand and the low standard of per capita usage ensure that this is not an unduly melodramatic statement. There is no evidence that a modern, rapidly expanding economy can be achieved without an almost immediate call on incremental energy use.

The evidence of how rapidly energy demand grew in the U.S. post-World War II, in Japan from 1960 to 1980, or in South Korea, Singapore, Hong Kong and Taiwan from 1970 to 1990 suggests that it would be naïve to assume that China's energy needs would not grow just as fast. Otherwise, China's economic expansion simply cannot occur.

China's future energy needs are further complicated by its unusual "fuel mix." Throughout the rest of the world, petroleum use represents about 40 percent of total energy needs with coal, natural gas, hydropower and nuclear energy making up the balance. In China, almost four-fifths of current energy needs are supplied by consuming coal. The remaining one-fifth is primarily petroleum-based with only a fraction being supplied by the other three energy sources: natural gas, nuclear energy and hydropower. Table 1 details the worldwide fuel mix along with the fuel mix from a variety of other countries. With the exception of India, which uses about 75 percent as much coal as China as a percent of total energy consumption, no other country comes close to China's intensive use of coal.

Table 1
Fuel Mix Analysis
Country Sampling

Country	Oil	Natural Gas	Coal	Nuclear	Hydro	Total BOE (Million)	Population	Per Capita
CHINA	19%	2%	77%	--	2%	4,992	1,190	4.2
India	32	7	57	1%	3	1,435	900	1.6
Indonesia	59	34	6	N/A	1	438	190	2.3
Malaysia	55	37	6	N/A	7	187	20	9.4
Taiwan	52	5	26	16	1	405	21	19.3
South Korea	60	4	20	12	--	836	44	19.0
Thailand	22	7	4	N/A	--	788	58	13.6
Japan	57	11	17	13	2	3,304	125	26.4
United States	<u>40</u>	<u>25</u>	<u>23</u>	<u>8</u>	<u>4</u>	<u>16,425</u>	261	62.9
TOTAL WORLD	<u>40%</u>	<u>23%</u>	<u>28%</u>	<u>7%</u>	<u>2%</u>	<u>57,527</u>		

China's dependence on coal has already taken a heavy toll on its environment and air quality. As a result, from the highest levels of China's state leadership to editorial writers in China's press, to the average man on the street, there is now an unusually high degree of awareness of China's need to reduce its coal usage. Absent making this change, China's economic expansion could literally poison the country. But, as China's energy mix changes, even higher growth is demanded from the other conventional energy sources. There is no clear indication which alternative energy source could most easily fill the gap created from reducing the country's use of coal. Expansion of either nuclear energy or hydropower capacity to replace a meaningful amount of coal can realistically only shift China's coal use by a few percentage points. Moreover, the lead time to create significant expansion of either nuclear power or hydropower takes decades, not just years. Thus, only massive amounts of added crude oil and natural gas supplies can help China reduce its use of coal while its overall energy needs continue to rise.

How China solves these enormous energy needs (which will create a staggering growth in its oil and natural gas demand) will be one of the great challenges over the coming decades. It will be the single biggest governor of the rate at which the Chinese economy can expand. It will also

have a significant impact on the worldwide supply of oil and gas since China will be forced to tap the supply of many other parts of the world. As awesome as these needs are, it is imperative that they are met so that China can limit the devastating impact of its consumption of coal.

China is blessed with a rich endowment of energy resources, unlike most other parts of Asia where most of the energy needs are imported. The country's problem is not a lack of resources, but a population base that is already too large relative to its resources.

Given how little energy China's population now consumes, it is remarkable that the country is already the second largest energy consumer in the world, second only to the United States. China is already the world's largest producer of coal with an annual coal consumption amounting to 29 percent of world consumption. China is also the world's sixth largest producer of oil, having discovered over 400 oil fields over the past 40 years. The country has over 17,000 km of oil and gas pipelines and its refinery capacity exceeds 2 million barrels per day.

While China's natural gas usage is almost insignificant in terms of its total energy demand, the country is also the world's 20th largest natural gas producer. Although China is just beginning to focus on natural gas as a pillar of its future energy needs, it produced small amounts of natural gas from the Sichuan Basin as early as the third century B.C. when salt miners piped gas through bamboo reeds to refine salt. When China finally became a major oil producer in the 1960s, it did little exploration for natural gas. However, China is now placing high hopes that its extensive natural gas deposits will allow the country to start tapping into this environmentally friendly source of energy and help the country wean itself from coal.

The task of reducing coal usage by using more oil and gas can be simply illustrated. If China's current energy consumption stayed flat and China decreased its coal usage from 77 percent to 50 percent, the country would require an additional 4.6 million barrels per day of oil supply. If China reduced its coal usage to the worldwide average of 28 percent of total energy through more oil and gas, an additional 9.7 million barrels of oil equivalent would be needed each day, an increase of almost three-fold in current oil and gas supplies. But, assuming that China could keep its energy needs flat is unrealistic because its total energy use must expand as its economy grows.

Nuclear power has played a tiny role in China's energy needs to date. The country is now building four new nuclear plants. But, even when these are complete, nuclear power will account for only a small percentage of China's energy needs.

China has an extensive river system that winds through chains of mountain ranges, allowing the use of hydropower from building dams. While China's hydropower is important and will grow, this source also provides only a fraction of China's total energy requirements. China's massive Three Gorges Dam project will be one of the world's most costly energy projects ever undertaken, but it will only replace a tiny amount of China's current coal use.

Two of China's neighboring regions offer the potential for enormous supplies of imported oil and gas: Siberia to China's north and the emerging countries of Central Asia to the west of China. Both have abundant oil and gas supplies with no local markets to serve. While neither area has any existing pipeline infrastructure to deliver either hydrocarbon to the burgeoning China market so far, both regions are anxious to begin supplying China with some of its energy needs. Massive oil and gas pipeline projects to bring Siberian and Central Asian oil and gas to China are already being planned. As these two regions become more tied into China's energy supply system, this could begin to alter the political alliance of both areas with China.

Until the 1960s, China relied on imported oil from foreign areas for nearly all of its petroleum needs. During the time the People's Republic was founded, China's crude oil production was less than 5,000 barrels per day and its only significant home-based energy resource was coal. As a result, the country's entire power and electrical complex was designed around the use of coal.

However, in the late 1950s, China started to have a string of remarkably successful oil discoveries beginning with the Daqing Field which still ranks as one of the world's giant oil fields. On the back of this discovery, China's oil quickly became a second source of local energy supplementing its use of coal.

The Daqing Field still anchors China's oil output and has now produced in excess of 1 million barrels per day for 21 consecutive years. On the heels of Daqing came several other prolific fields, or actually basins of multiple fields. These new fields included Shengli, Huabei and Renqiu. By 1970, China's oil production had grown to 400,000 barrels per day. By 1980, its oil

production grew another five-fold, exceeding 2 million barrels per day. By the mid-1990s, China's oil production had grown to 3 million barrels per day, making China the world's fifth largest daily producer of oil.

As China's oil production grew, it quickly surpassed China's internal needs, making China an important oil exporter. By 1985, China was exporting over 620,000 barrels per day. Part of its oil exports were offset by a growing dependence on imported finished petroleum products, which was partially a function of China's domestic oil production and most of its refinery system being located in its north and northeast regions while the fastest growing part of its economy was located further south. Nevertheless, China still remained a net exporter of total crude and finished petroleum products until November 1993, when growth in oil demand forced China to become a net importer of oil for the first time since the late 1960s. Looking forward, it is unlikely that China will ever be an oil exporter again because its internal needs will simply be too high.

China's import needs have continually risen since the end of 1993 while it has been able to make only modest improvements in its daily oil production. In 1994, China's net oil imports totaled 300,000 barrels per day. In the first quarter of 1997, its oil imports were double the total of one year earlier. By April 1997, the country's net oil and petroleum product imports had risen to a record 960,000 barrels per day.

In 1970, China's oil consumption was only 560,000 barrels per day. By 1975, it had grown to 1,350,000 barrels per day, and reached 1,810,000 barrels per day by 1985. In 1997, China's oil demand is expected to reach 3.8 million barrels per day. In spite of this growth, the country still has one of the lowest per capita rates of oil consumption in the world. Table 2 details 1994 per capita petroleum consumption for a group of highly industrialized countries, a group of fast growing countries and the "just beginning to grow" category. Out of a total of 47 individual countries, China's 1.1 barrel per person oil and gas consumption ranks 41st in the world. Only a handful of countries rank lower.

Table 2
1994 Petroleum Consumers
(Per Capita)

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Countries Now Highly Industrialized			Fast Climbing Countries			Countries Just Beginning To Grow		
	Population (Millions)	BBL/Person/Year		Population (Millions)	BBL/Person/Year		Population (Millions)	BBL/Person/Year
U.S.	261	24.8	Mexico	89	7.7	China	1,190	1.0
Canada	30	21.6	Venezuela	21	7.3	Nigeria	108	0.9
Belgium	10	19.0	Iran	62	6.9	Pakistan	126	0.8
Netherlands	15	18.0	Malaysia	20	6.5	India	913	0.5
Japan	125	16.6	Bulgaria	8	6.1	Sudan	27	0.4
Australia	18	16.2	Hungary	10	5.9	Zaire	43	0.2
Finland	5	15.8	Argentina	34	5.1	Bangladesh	118	0.1
Norway	4	15.4	Chile	14	4.6			
Denmark	5	14.7	Romania	23	4.1			
Sweden	9	14.7	Ecuador	11	3.8			
Switzerland	7	14.7	Thailand	58	3.7			
South Korea	45	14.0	South Africa	40	3.6			
Israel	5	13.7	Brazil	159	3.3			
Germany	82	12.9	Turkey	61	3.2			
Greece	10	12.2	Egypt	57	3.0			
Italy	57	11.8	Algeria	27	2.9			
France	58	11.5	Poland	38	2.8			
Austria	8	10.7	Colombia	36	2.5			
Spain	39	10.4	Philippines	67	1.6			
Portugal	10	10.0	Indonesia	190	1.4			

China's overall energy growth has been less dramatic than its growth in oil use alone, since oil began from an unusually low base 20 to 30 years ago. Even so, the country's total energy demand growth has been noteworthy. On a per capita basis, China still ranks as an extremely low energy user. Its current per capita energy demand is one-tenth of the U.S. level and 40 percent of the world average. As noted previously, most of the growth in China's energy needs has historically been supplied by coal. Table 3 details China's per capita energy consumption compared to the world average, the U.S. and the other Asian countries.

Table 3
Total Energy Consumption
(Per Capita)

TOTAL WORLD	10.3 BOE/Person/Year
U.S.	57.0
Singapore	61.0
Japan	29.0
South Korea	24.0
Taiwan	22.0
Malaysia	13.0
Thailand	6.0
China	5.0
Indonesia	3.0
Pakistan	2.0
India	2.0
Philippines	2.0
Bangladesh	> 1.0

<u>Last 10-Year Population Growth</u>	
U.S.	1.0% Per Annum
Asia	1.8
China	1.4
Indonesia	2.0
India	2.1
Pakistan	2.6
Philippines	3.0

Source: U.S. Department of Commerce, BP, MITI (Baker Center at Rice).

As these extremely low per capita energy or oil use statistics highlight, China must dramatically increase its use of all sources of energy if the country continues to transform itself from one of the world's most backward countries into a thriving, modern economy.

The direction of China's future energy needs is clear. The issue becomes one of both magnitude and fuel mix. And, as China's fuel mix changes, finding reliable alternatives is no trivial task since every percentage less coal used means that almost any alternate energy form needs to soar since all other sources are so disproportionately low.

Every serious long-term energy forecast shows that China's energy needs are increasing. All long-term oil forecasts predict that China's oil needs will increase. The estimates range from a doubling of oil demand by 2010 to triple China's current use by 2015. But, when these increases are divided into China's projected population in 2010 or 2015, they still imply a very low per capita use compared to almost any other country in the world.

Some argue that China is so unusual in its demographics and its economy that it will always have abnormally low per capita energy use. However, is this argument realistic or will China's per capita energy follow the same growth as so many other countries that embarked on a modernization of their country?

To unravel this puzzling question, which will dramatically impact the course of the world's energy business for the next 20 or 30 years, begin by carefully analyzing what is happening to China's economy today as the changes that began 17 years ago now accelerate. As each piece of China's economic growth plan is better understood, the implied need for more energy must be carefully kept in mind.

Having completed this assessment, I have come to the conclusion that it is very unlikely that China could still have such abnormally low per capita energy use in 2010 or 2105, which is implied by nearly all long-term oil forecasts. China's likely needs should be far greater. But, to understand why higher energy needs are so likely, one must begin by looking carefully through an energy eyeglass at China's economy today and where it is headed. Then, the issue of which sources of energy will make up China's future needs and how China secures such massive added supplies becomes more important and far less hypothetical.

Obviously, China's Economic Renaissance could unravel. But, from an energy planning perspective, this should not be a foregone conclusion or likely scenario. Absent a halt in China's improving economic outlook, the country's energy needs become almost insatiable. And as China's total energy needs grow while it begins to wean itself from coal, the need for all other alternate forms is insatiable. To arrive at this conclusion, begin with a look at what is really taking place in the Chinese economy today.

*An Examination Of
China's Economy*

Introduction

It is impossible to analyze the magnitude of China's energy needs without first developing a general sense of the country's current economic state of affairs along with some assessment on the future direction of China's economy. China's future energy needs will merely follow the country's rapidly changing economy until the high cost of meeting energy demand becomes a drag or an anchor for future economic expansion.

While scores of books have been published on the changes taking place in China, I have been surprised at the lack of in-depth reviews on the underpinnings of China's economic growth. So many of the recently published books on China focus primarily on the human and political issues involved in its rapid changes or in the political and economic threats that these rapid improvements might trigger for the rest of the world. However, when one puts all the human rights and political issues aside and focuses simply on the economic changes underway and the impact these changes will have on China's future energy needs, you start to sense that both its growth and its energy needs will likely accelerate over the next few years.

I have assembled a variety of details about what is happening within China's economy that seem most relevant to what will drive China's future energy needs.

The accuracy and overall quality of this data must be questionable since I am acutely aware that good, high quality statistics that impact energy demand can be hard to obtain even in highly developed countries like the G Seven. Witness how often U.S. economic statistics are revised by significant margins six months to a year after original estimates are made, or how imprecise demand estimates for U.S. oil demand often are.

It is impossible to gauge the accuracy of many of the data points contained in this background examination of China's economy. The data comes from almost a hundred different sources. Some must be wrong, but given the variety of inputs, it would be hard to envision that all of the data is wrong. Moreover, as China's economy is still tightly controlled by its government, the Chinese government statistics are probably collected with a surprising degree of accuracy.

But, before examining the various forces creating the rapid changes in China's economy today, it is useful to examine two key aspects that influence virtually every part of China's economy.

The first is China's population and second is the size of China's economy today when measured by the purchasing power of the yuan.

CHINA'S POPULATION

What makes China's economy and its energy needs so unusual is its population. A cursory overview of this population base, in relation to its current economic size, helps in better understanding the future pressure China will face to consume more energy.

In 1997, China's population is just over 1.2 billion people and accounts for over 20 percent of the earth's population. China has been the most populous country for possibly thousands of years. Historians suggest that China's population was about 60 to 70 million people in the year 1000. By 1850, the country's population had grown to 430 million. In 1953, its population was estimated at 582 million people. For the next two decades, large families were encouraged until a population control program was initiated. However, even after the "one child" policy was implemented in 1979, China's population continued to grow to the current total of over 1.2 billion people.

Curiously, while this rate of growth seems overwhelming, it actually only amounts to an annual growth of three-tenths of 1 percent per year over the last millennium. This growth accelerated to seven-tenths of 1 percent for the past 150 years.

There is an interesting uneven geographic distribution to China's population. About 900 million people live in the rural areas of China. This rural population base has traditionally been called the Chinese peasant class, though the term essentially means a farmer as opposed to being impoverished. The two phrases have, however, become almost synonymous since all "well to do" agriculturists were wiped out in the various civil wars and revolutions over the past 70 years.

While only 300 million Chinese live in the country's cities, this is still more than the population of the U.S. and Canada combined and these dwellers live in numerous cities. There are now 105 cities throughout China that have a population in excess of 1 million people.

Historically, a vast percentage of China's population lived in poverty. The remarkable progress that China has made in reducing its poverty over the last 45 years was documented by the United Nations Development program in June 1997. The report noted that China had reduced infant mortality from 200 per 1,000 live births to 42 deaths between 1949 and 1995 while also increasing life expectancy at birth from 35 years to 69.

In the 1950s, 80 percent of China's adult population was illiterate. Today, this has fallen to 19 percent and almost all Chinese children now attend school.

In 1978, the Chinese government carried out a special investigation which concluded that one-third of the country's rural population (some 260 million people) lived below the poverty line. These findings led to a variety of government programs that were created to attack poverty including land reform, market operation and price reform of farm products. As a result, in less than 20 years the number of rural people living in poverty fell by 75 percent to only 65 million people.

If China is divided into thirds on a north to south axis going east to west, about 60 percent of the China's total population lives in the coastal third of the country. Another 35 percent of the people live in the middle third of the country while the western third of the country holds only 5 percent of the total population. If it were not for the rich natural resource base of China's "Empty Third" in the west, this area could be split as a separate country and have almost no impact on China's overall economy.

Despite China's strict one child per family policy, which was introduced in 1978, its population base has still grown by almost 1.5 percent per annum primarily as a result of the reduction in infant mortality rates and longer life expectancies for China's aging people. Moreover, the one child policy is now beginning to change.

It is important to understand two other factors in order to appreciate how the demographics of China's population plays into the country's future economic development. First is the homogeneity of the population. Unlike almost every other heavily populated country, China's population comes almost entirely from a single ethnic group - the Han, who make up almost 85 percent of its 1.2 billion people. The 15 percent ethnic minority group in China is comprised primarily from four main groups: the Muslim in the most western regions of China, the Mongolians in the far north, minority ethnic groups along China's southern border and the Tibetans in the southwestern region of the country.

It would take a sociologist or anthropologist to properly assess the impact, importance or even the irrelevance of any country having such a high a percentage of its people from a single ethnic

background. However, one can note the difficulties the U.S. economy went through as we absorbed one after another wave of different ethnic groups into our economy. You can also examine India's difficulties over its first 50 years of independence where democracy thrives, but so little progress has been made because of the diverse cultures and religions that make up this large country. Turn to Russia where centuries of ethnic conflicts between various groups make it difficult to find a peaceful cooperation. Or, shift to the fractionated Balkan region where ethnic animosities stretching back almost 1,000 years continue to erupt from one neighborhood to another. All illustrate the difficulty of absorbing multi-ethnic groups into a rapidly changing economy, and also highlight the advantage that China has with its unique ethnic homogeneity as it undergoes a fast moving economic reform.

The second factor that should impact how rapidly China's future could improve is the country's long history as one of the most sophisticated, highly educated, skillful people in the world. While other parts of the world periodically flourished for various spans of time, ranging from the Romans and the Greeks to the Egyptians or Incas in South America, no part of the world except China consistently remained a highly developed, increasingly advanced society for such a long period of time, stretching out over 2,000 to 4,000 years.

Since China kept quite insular without any pattern of international aggression or expansion outside its normal boundaries, the remainder of the educated world had little idea of how advanced China's society had become over the course of the past several thousand years. Even when Marco Polo traveled back from China less than 1,000 years ago, his tales of a magical country of highly educated artisans seemed far-fetched to most of Europe's educated people.

Through scores of various dynasties over many centuries, China consistently remained strong and remarkably advanced in many of the leading scientific and educational improvements occurring in the world until it began to fall behind other developed countries beginning almost 200 years ago.

Now the Chinese people are rediscovering much of the country's remarkable history. As this educational process gets underway, they, along with the rest of the world, are beginning to understand the richness and depth of Chinese culture and how talented the Chinese have always been. Only in the "Dark Ages" (a term now often used by the Chinese to describe the

period beginning with final decline of the Ching Dynasty), did China begin its downward tailspin. This continued with the Opiums Wars, the destabilizing effect of Western powers dominating Chinese trade, the brief attempt at Sun Yat Sen's vision of real democracy, followed by warlord battles and Japan's invasion. Finally, the Civil War lead to the creation of the People's Republic of China and "The Great Leap Forward", which induced China's most serious famine ever, and the Cultural Revolution.

While China suffered through this series of unfortunate events, the rest of the world was embarking on industrial and technological revolutions. When China once again opened its doors to the rest of the world, it emerged as a very backward country. The country now faces a steep climb back to regain the historical strength that dominated the Chinese culture for so long.

As the United States began its growth, our population was tiny and came from the outcasts of several other European countries. We succeeded despite these odds. For China to succeed, though, they "merely" need to turn back the clock to the centuries when there were few more civilized populations on earth.

THE SIZE OF CHINA'S ECONOMY

While China's massive population base is the country's most unique economic demographic, the size of its current economy is almost as unusual. By most conventional standards, the country's current economy is minuscule, even on a total size, let alone on any per capita measurement. But, measured on a purchasing power parity basis, China's economy is already very large.

According to the State Planning Bureau in Beijing, the official measured size of China's GDP listed the country at \$6.8 trillion yuan, the equivalent of \$815 billion in U.S. dollars at the end of 1996, which is only about \$750 per person per year. This makes China's current economy one of the smaller countries in the world.

There is another economic theory which suggests the actual size of China's current economy is much larger than it appears. While most Chinese earn very little, they also pay very little for their needs. If a purchasing power parity measure is used to gauge the actual size of China's economy today (a test increasingly favored by many economists over the simple per capita gross domestic product formula), China's GDP is somewhere between \$3.5 trillion (in U.S. dollars), as recently reported by the *New York Times*, or even as much as \$5 trillion, making its economy already one-half to two-thirds the size of the U.S. Using this measure, China's economy is not far behind the U.S. and could easily tie or surpass the U.S. by 2010 to 2020.

One of the best illustrations of the differences in parity purchasing power is detailed in *China Wakes* by Nicholas Kristof and Sheryl Wudunn. The authors illustrate China's abnormal parity purchasing power by outlining the finances of an actual family of three living in the south China city of Guiyang. Both parents work and they live in a two bedroom apartment with their 10-year old son. They have a television, a sofa and a refrigerator. The husband earns a basic salary of \$23.70 per month as a factory technician and his wife earns \$18 per month. However, when the various cash bonuses plus an 80 cent per month bonus for having only one child is added to their base salaries, the couple's monthly cash income jumps to almost \$85.

While this is not much money by our standards, their expenses are very low. All medical expenses are free. They only pay \$1 per month for their apartment. Food costs \$37 per month, and it buys a lot since food is relatively inexpensive. For example, a pound of spinach costs

8 cents, a pound of rice costs 12 cents, and a pound of pork costs 60 cents and cigarettes cost as little as 7 cents per pack. The evening newspaper costs 2.5 cents and bus transportation, while very crowded, costs only a penny per ride! A little money goes a long way in China.

Another example of China's purchasing power difference comes from *The Economist's* "MAC Chart" which it periodically publishes using the cost of purchasing a Big Mac hamburger (one of the most standard food purchases in the world) in various countries throughout the world, in order to measure which currencies are under or overvalued.

Based on April 1997 prices, the yuan currently purchases twice what a dollar buys. Or, more simply put, a Big Mac costs only \$1.25 in Beijing but costs \$2.50 in the U.S. Based on this standard, no other currency in the world is more undervalued than the yuan. Also bear in mind that a McDonald's meal is an extremely expensive purchase for most Chinese compared to rice and spinach at 12 and 8 cents respectively per pound. So even this "Big Mac" measurement seriously underestimates the actual size of China's economy today.

THE STATE OF CHINA'S ECONOMY

While statistics probably under estimate the actual comparative size of China's current economy given this unusual purchasing power disparity to most other economics, it is still clear that China's economy is "large" and rapidly growing regardless of which measurement standard is used.

The State of China's 1996 Economic Affairs was candidly summarized by Li Peng, China's Premier, at the Eighth National People's Congress on March 1, 1997. He began his speech by reporting that China's GDP, which totaled \$815 billion at the end of 1996, had grown by almost 10 percent over the past year. The country's investment in fixed assets increased by 18 percent in just one year to \$284 billion. Of this total investment, 43 percent was directed to projects in the less developed central and western parts of China.

In 1996, International tourism channeled \$10 billion into China while direct foreign investment netted the country another \$40 billion. The country added 15 million kw hours of electricity during the year and completed 1,100 km of modern railway between Beijing and Kowloon and 20 million new phones were added. China's savings deposits totaled \$464 billion at year end, an increase of \$106 billion from a year earlier.

China's average per capita income was \$518 for city dwellers and \$229 for rural Chinese, an increase of 3 percent and 9 percent respectively over 1995 levels in actual terms. At the end of 1996, China's foreign exchange reserve totaled \$100 billion, exceeding even Hong Kong's large foreign exchange balance.

In his March 1st speech, Premier Li Peng predicted that China's economic progress would be maintained in 1997 with an 8 percent targeted rate of growth to make sure that price increases are slightly lower than 1996 increases. But, its economic growth in the first half of 1997 turned out to be almost 20 percent higher.

Another glimpse at the robust nature of China's current economy was presented in the China State Statistical Bureau's Economic Statistics Communique for 1996 which reported that integrated circuit usage increased by 49 percent, ethylene consumption grew by 25 percent and

tractor sales grew by 32 percent. Can you imagine the impact of such high rates of growth on the U.S. economy?

As impressive as China's 1996 results were, they are improving even more in 1997. In the first half of the year, China's trade surplus rose twenty-fold to almost \$18 billion with total exports of \$81 billion compared to imports of \$63 billion. More than 20 percent growth was recorded in exports of electronics, garments, textile yarns, plastic products, footwear, toys and grain.

In the first five months of 1997, China's investment in fixed assets increased another \$43 billion, up 14 percent over the same period in 1996. Even better, China is making this rapid advance while keeping its once raging inflation in check.

With such high rates of growth occurring in so many parts of China's economy, the sheer volumes of China's total consumption in both consumer and industrial products is already beginning to represent a meaningful percent of worldwide demand in certain products. But, this also leads back to another paradox about China's economy today—its per capita consumption rates of nearly everything used is tiny while the total volumes consumed for these "tiny" items is immense when measured for the country as a whole.

For instance, a recent study by the World Watch Institute noted that China's 1995 grain consumption was already nearly double that of the United States. In 1995, Chinese farmers used 28 million tons of fertilizer compared to U.S. farmers who used only 20 million tons. The Chinese now consume 42 million tons of beef, pork and mutton compared to 20 million tons for the same products in the U.S. Steel production in China totaled 92 million tons in 1995 compared with 91 million tons in the U.S.

This World Watch study pointed out that by the year 2010, China's population could likely consume the world's total current annual fish catch and would require the entire annual U.S. grain production to meet its demand for beef. It is hard to believe such predictions could become fact, but the world has never undergone a phenomenon like China's awakening before.

REGIONAL DIFFERENCES IN CHINA'S ECONOMY

I have already pointed out how different China's population demographics are between its crowded coastal region compared to the nearly empty western region of China or the disparity in the size of China's rural population compared to its city dwellers.

There is almost as much difference in the economic development of the various regions of China. The leading regions in China, not surprisingly, are the special economic zones that were singled out as "test tube" reform centers 16 years ago. Ahuhai in China's Guandong province is an excellent example of the success of these experimental zones. The city now enjoys a per capita gross domestic product of \$3,600 per person with the average resident enjoying an annual income of \$2,048.

Look also at the vast contrast in the economic development between China's four largest cities: Shanghai, Beijing, Tianjin and Chongqin. Shanghai, with about 12 million people, has a GDP per person of just under \$2,800. Beijing follows with a GDP per person of about \$1,800. Tianjin's GDP is about \$1,400 per person while Chongqing, which is now the largest city on earth with 30 million inhabitants has a GDP of under \$500 per person each year.

In stark contrast to all four of these cities is Hong Kong, which had a GDP of over \$23,000 per person in 1996. But, it is also interesting to note that Hong Kong's GDP has doubled since 1990 and has grown four-fold since 1985. As late as the 1970s, Hong Kong's economy was so backward that it was deemed by many to be an unaffordable drain on the U.K. economy. The resulting Hong Kong miracle, which has been widely chronicled during the handover, once again demonstrates how quickly an underdeveloped country in Asia can expand when the "wind gets into its sails". (When Hong Kong reunited with China on July 1, 1997, China's population only changed by one-half of 1 percent, while its GDP will increase by almost 20 percent.)

BACKGROUND ON THE WORLD'S LARGEST CITY

On March 1, 1997, the Chinese government created a new city in Northern Sichuan by merging four cities. This “new town”, Chongqin, suddenly became the largest city in the world with 5 million more residents than Tokyo.

The new Chongqin merges the old city of Chongqin with Fuling, Wanxin and the Qianjiang Prefecture. Its territory covers 82,000 sq. km, an area larger than Switzerland and the Netherlands combined. Its population is the same as both countries if Austria's 8 million people are also added to the total.

While Chongqin has a GDP that is about one-sixth the size of Shanghai, its GDP has grown by over 10 percent per annum for the past four to five years. It is quickly becoming a thriving economic center of the upper reaches of the Yangtzi River. Over 1 million new inhabitants will move into the city through forced relocation because of the Three Gorges Dam. This gigantic hydropower project will also radically improve barge traffic into the upper regions of the Yangtzi River while also taming the ravage floods that periodically destroyed much of the region's agricultural base over the last several centuries. This infrastructure project alone should provide a phenomenal “shot in the arm” to the newest largest city in the world.

The city plans to totally eradicate poverty by 2000 and by 2010 it hopes to quadruple its 1995 GDP, creating a “medium developed city” (a Chinese standard) in terms of Chongqin's comprehensive economic strength.

The city is pinning its planned growth on three of China's “pillar” industries: automobiles (especially motorcycles), chemicals and metallurgy. Last year, it produced 1.8 million motorcycles, 25 percent of China's total production. Its chemical base is supplied by a nearby natural gas field, which contains China's largest onshore gas reserves.

To improve its investment climate, the city is investing heavily in new infrastructure. It is building three ports, five bridges, two airports and five expressways, along with four railways linking the city with Dachun, Suining, Wuhan and Huaihua.

By the end of 1996, the city had approved 2,560 foreign investment projects that will inject \$2.8 billion into the city's still tiny economy. Foreign investment already accounts for 15 percent of its total investment in fixed assets and in the first half of 1997 the number of foreign investment projects increased another 17 percent.

In the first six months of 1997, Chongqin's industrial output rose by 39 percent, led by its "pillar" automobile industry which produced 84,000 automobiles, up 54 percent over the same period a year ago.

Long known as the "city of smog", Chongqin is taking steps to address its serious pollution, especially sulfur dioxide and acid rain. Its rate of sulfur dioxide per cubic meter of air in 1995 was the second highest of China's 72 major cities. The municipal government plans to spend \$840 million on 82 separate environmental projects over the next three years.

The city's history dates back over 3,000 years. During the War of Resistance against Japanese Aggression, which we call World War II, Chongqin was the Kuomintang government base of power. While Chongqin might now be the least known big city in the world, its current anonymity will change quickly if all these positive improvements continue. At the least, it is inconceivable that its per capita GDP will remain at about one-fiftieth that of China's newest city, Hong Kong. And, all of these improvements add up to ever increasing energy needs.

ROLE OF GREATER CHINA/OVERSEAS CHINESE

China has another quiet but powerful ally for its economic transformation: the concept of “Greater China” and the strong financial, emotional and cultural ties of the powerful and resourceful “Overseas Chinese”. In a sense, this “Greater China” becomes a powerful fifth column to assure China succeeds.

As Samuel Huntington pointed out in *The Clash of Civilizations*, Greater China is not simply an abstract concept. The present economies of East Asia have already become increasingly China-centered and Chinese dominated, though the “Overseas Chinese” (a term used for all Chinese who do not reside within China proper) make up only a small portion of the population in most of the East Asian countries and have generally been excluded from the power centers of most their governments.

In the Philippines, for instance, the Overseas Chinese make up only 1 percent of the Philippines population but are responsible for 35 percent of the sales of domestically owned firms. In Indonesia, Overseas Chinese make up about 3 percent of the country’s population but own 70 percent of the private domestic capital. Chinese make up 10 percent of Thailand’s population but own nine of the ten largest business groups and are responsible for 50 percent of Thailand’s GNP. Chinese make up about one-third of Malaysia’s population but almost completely dominate the economy.

The Overseas Chinese have proved to be one of the most industrious and resourceful groups of people in the world, which illustrates the potential of mainland Chinese when they are given the proper resources and economic incentives.

Huntington describes the success of the Overseas Chinese as a “bamboo network” of tight family ties, strong personal relationships and the unique Chinese culture. Almost regardless of which country they come from, Overseas Chinese have developed entrepreneurial skills and a deep sense of family values. These combine to easily produce rapport and trust, the basis for all business relations.

The Overseas Chinese are already having a major impact on China’s economy. The predominant foreign investment in China comes from Hong Kong, Taiwan and Singapore.

Together, they made up almost 80 percent of China's 1996 foreign investment. Japan, the U.S. and Europe combined for only a small percent of the \$40 billion invested in China last year.

For the past 70 years, many Overseas Chinese have been banned from visiting their ancestral homes. For a culture that values roots so highly, it is hard to imagine the importance of seeing this barrier fall.

Despite the political tension between China and Taiwan, for instance, there were over 4.2 million Taiwanese visitors to the mainland in 1993 along with 40,000 letters and 13,000 phone calls per day. Huntington's term, the "bamboo network", is not a fuzzy theoretical concept. It symbolizes a pride, commitment and shared values unmatched in many other part of the world.

If the Jews of America and other parts of the world were a powerful and important resource in helping create a strong Israel from 1947 onward, the Overseas Chinese role in re-awakening China could prove to be even more significant.

THE IMPACT OF CHINA'S ECONOMIC INVESTMENTS

Many paradoxes surround China's economy, from its apparent tiny size (or a far bigger size if purchasing power parity is used), to how little individual Chinese now consume compared to total Chinese consumption. But, perhaps the biggest paradox of all is attempting to quantify the future impact of the current investment surge in China's economy from direct foreign investments and government directed infrastructure investments.

Even if China's officially stated economic size of \$820 billion is grossed up to \$3.5 or even \$5 trillion, the multiplier impact on the economy's future from a combination of foreign investment, which has grown from \$10 billion per year in the early 1990s to almost \$50 billion per year today plus a projected \$800 billion that China plans to pour into infrastructure investments over the next decade is hard to imagine. It is probably unparalleled in any other rapidly growing economy. When the impact of these huge sums is related to China's actual economic size today of just over \$800 billion, where so little money can buy so much, the multiplier impact becomes completely unprecedented.

It was enlightening to recently read the various stories that commemorated the 50th anniversary of the Marshall Plan and to realize how little outside money was actually invested in most European countries (totaling only 5 to 10 percent of each country's net investment), yet this small investment ended up having an enormous impact on rebuilding Europe. In a similar vein, the major works projects undertaken by the U.S. government in the 1930s to prop up our economy during The Depression was a pittance compared to the new investments pouring into China today.

When you scale \$40 billion of foreign investment on China's \$800 billion economy to the U.S. economy, an equivalent of \$3.75 trillion would have to be invested in one year to have a similar impact.

The sums being invested in China by the government, The World Bank, domestic investors and outside private capital sums make what happened in Europe 50 years ago as a result of the Marshall Plan look almost trivial. Moreover, most of these sums are not being used to rebuild destroyed cities, but are being wisely spent on specifically selected infrastructure projects that merely "grease the skids" for follow-on investment. The multiplied impact of these investments

wash through the rest of China's economy, providing a unique and powerful boost to an already fast moving economy.

CHINA'S ECONOMIC ACHILLES HEELS

Given the powerful forces now aiding China's economic reform, it is perhaps a "blessing in disguise" that several serious problems still exist. But, at their worst, these problems could not only drag China's current economic growth to a halt, but also create a new round of political unrest or an even bigger economic collapse.

Leading the list of "China's Economic Achilles Heels" is its stagnant, debt laden State-Owned Enterprises and the breakdown in Chinese morality—particularly evidenced in bribery and corruption along with the emergence of widespread crime. Finally, comes the threat of chronic inflation, which has prevented other countries, including almost all Latin American nations, from advancing as fast as they desired.

State Owned Enterprises

The biggest economic Achilles Heel in China today is its vast network of state-owned enterprises. Not only are they massive, but they are economic dinosaurs compared to the role models that China's leaders want the country's private sector to become. While these enterprises comprise a very large part of China's economy, their relative size could rapidly shrink if the other parts of China's economy grow as rapidly as they have in the recent past.

Over 60 percent of Chinese government revenue is now derived from state-owned enterprises and two-thirds of the city and town employees work in these state-owned companies. These enterprises still dominate the fields of infrastructure, basic industry and the high technology industry in China.

The management systems of these state-owned enterprises are generally not compatible with any modern market-driven management system. The state-owned enterprises typically upgrade their technology slowly, neglect any marketing input as to what rate of production they adopt, and lag in almost all Western standards of business operations and management. Most of these state enterprises have surplus production capacity aggravated by the lack of any means to "select the superior and eliminate the inferior".

As ingrained as these problems are for the state-owned enterprises, the Chinese government is aggressively tackling them, first by encouraging rapid growth in nonstate-owned enterprises so these corporate dinosaurs become a smaller part of China's economic core. The second reform is an ambitious program to reorganize and upgrade these enterprises through better management practices and by giving more freedom and flexibility to the smaller state-owned companies, encouraging privatization and mergers. China also has more efficient bankruptcy procedures allowing the free market to sort out who the winners and losers will ultimately be.

At the core of these reforms is a conscious effort to strengthen the management and operations of the enterprises. Li Peng addressed this need in his "State of the Union" talk to the Eighth People's Congress in March when he stated, "*Scientific management is essential to running enterprises well. The state-owned enterprises need to change their management concepts and truly gear up production to market demand, establish management systems which are*

responsive to competitive environment. They should handle their work in a down-to-earth manner, improve their technology, operational costs, product quality, financial affairs and marketing and speed up technological progress. They need better after sales service. Finally, these enterprises need to eliminate losses and increase profits.”

Pulling off these reforms will not be an easy task. But, if China's economy can continue its fast paced expansion, it will create new jobs and make it easier on China's economy for the most efficient state-owned enterprises to fail. If China succeeds in restructuring even a significant minority of its state-owned enterprises, its economy could really take off. To the credit of China's current leaders, they recognize these problems and seem to have a realistic grasp of what needs to be done to create genuine reform in those state-owned enterprises that should survive.

It was encouraging to note that the machining sector of China's state-owned enterprises finally made a small profit in the first half of 1997 after recording sizable losses over the previous three years.

Chinese Morality

The second hindrance to economic growth is the rapid emergence of corruption which began during the first 15 years of this economic reform. There are many well documented reports from both the Western press and from Western companies doing business in China today on how widespread the graft and corruption has already become. But, there has been less attention paid by the Western press on the degree of concern in China's leadership and the efforts being made to eradicate this corruption.

In his address on March 1, 1997, Premier Li Peng made a variety of remarks about the lack of "Chinese morality" creeping into their system and the need for all Chinese, and particularly the business leaders, to become better citizens of both China and the world. Since Li Peng is so vilified in most Western press reports as the "monster of Tiananmen Square", I found his phrases and comments on this "morality issue" most interesting since his comments were more typical of "born again" Democrats in the U.S., than a political leader in China speaking to other Chinese delegates.

Some examples from his address are as follows: *"Corruption and other undesirable phenomena remain serious problems in China today. Bureaucratism, formalism and "prone to boasting and exaggeration" are spreading among some government functionaries..."*

"We should open additional markets and raise the level of these openings to the outside world. We should attach equal importance to economic development and to culture and ideological progress, and advance socialistic culture and improve democracy and the legal system in China today..."

"The way to mourn for comrade Deng Xiaping...is to further push forward the reform and opening up as well as the modernization drive which he initiated..."

"We must encourage those farmers who have become skillful in various technologies and who have gained managerial experience to return to their hometowns to start new business there and to assist in the endeavor to shake off poverty and become prosperous..."

“We shall introduce a unified system for basic old age insurance and expand coverage and we shall uphold the principle of separating the functions of government from those of enterprise...”

“Fellow deputies, the development of socialistic ethics is essential to the cultural and ideological progress for China. These will play a tremendous role in promoting our modernization. In building socialism with Chinese characteristics, apart from developing a thriving economy and perfecting democracy and legal structure, we must ensure that our people have good moral character...We should persist in conducting education in patriotism, community spirit and social ideology needs to be conducted in a down-to-earth manner...we must carry forward the fine tradition of the Chinese nation by emphasizing the importance of education in social occupational and family ethics...”

“China is a developing country. Only by working hard for a long time can we overcome backwardness. Extravagance, waste and ostentation constitute serious problems. We must vigorously develop the fine tradition of building the country and running everything thriftily and diligently. This is an important aspect of our endeavor to promote cultural and ideological progress and a major guarantee for pushing forward our modernization drive. Safeguarding social and political stability is indispensable to the modernization drive in our country. This year, we should continue effort so as to ensure that our people live and work in peace and contentment and that the reform and development proceed smoothly.”

“We must continue to take effective measures to concentrate on combating violent crimes, drug-related crimes, hoodlums and underground gangsters. In the past few years, we have intensified our efforts to combat corruption. Yet many problems remain to be solved. Our leaders throughout the country should take the lead in strictly following the relevant regulations which require them to perform their duties honestly.”

“We should respect citizen’s freedom of religious belief, and should not discriminate against those with or without religious belief. We should strengthen management of religious affairs according to law and help various religions adapt themselves to socialist society.”

“We should continue to improve and develop democracy at the grass roots level. . . to fully arouse the people’s motivation to deal with their own affairs as masters of their country.”

These remarks highlight the awareness of the Chinese leaders on the importance of creating an ethical, progressive economy. This morality emphasis is not common in many other emerging economies where the leadership rarely addresses the problems, let alone also spells out the way to combat them. If China's economy can improve while the country becomes more moralistic, this will further propel China's growth in an important and material way.

Inflation

China's third problem is its inflation, which has been brought under control in the past couple of years at some pain to parts of China's economy. Two interrelated factors make China's inflation problem a constant worry. The first is the risk of the economy "overheating", which almost always triggers various forms of inflation. Given the massive amounts of investment being poured into the Chinese economy, overheating will remain a constant high risk problem.

The second factor is China's abnormal purchasing power difference compared to the rest of the world. As these purchasing power parity differences narrow, China could increase its overall prices and wages by five to eight times to merely get its purchasing parity closer to the norms of the OECD countries and the other Asian Tigers. But, as this "repricing" happens, many economists would describe the process as hyperinflation. China's strong exports would also suffer as its currency strengthens.

What makes China's inflation problem even more complex is the impact of injecting foreign dollar investments in the magnitude of \$40 or \$50 billion into an economy, if purchasing power disparity is ignored, of only \$800 billion in size. The mere "co-mingling" of these different forms of value create either enormous purchasing power multipliers if yuan-based pricing stays flat, the ability to raise prices and wages, or some unusual combination or both.

During the U.S. depression of 1929, a loaf of bread only cost 5 cents. Today, bread costs only 25 times as much. But, much of this rise was due to economic prosperity, not a double digit rate of inflation. China will almost certainly go through a similar pricing transition. As all these changes ripple through the Chinese economy, accounting for what is true inflation as opposed to the equivalent of a "reverse stock split" to bring Chinese internal pricing to a world scale will not be an easy task.

HOW FAST COULD CHINA'S ECONOMY EXPAND?

Many analysts have assumed that China will have a difficult time continuing the rapid expansion of its economy. These analysts cite the meager means of the 900 million people living outside China's cities, the lack of a significant road system, the lack of cars and other constraints as barriers to China continuing to quickly improve its economy. Finally, skeptics of China's ability to continue to focus on the state-owned enterprise problems, which might ultimately sink the entire economy if political instability does not do this job beforehand.

All of these constraints are real, but it is enlightening to see how rapidly things have already started to change throughout China today. The country has already moved the largest number of people out of poverty in the history of the world and the change happened in only a decade and a half. While still a large number, there are now only 58 million people living below the absolute poverty line; 88 percent of China's households now have access to electricity and only 80 million Chinese households are still without power. This progress is much faster than the U.S. made 50 to 60 years ago.

In March 1997, the *China Daily* chronicled some of the rapid economic changes occurring throughout China. Refrigerator sales are six times what they were 10 years ago when only a small percentage of Chinese homes had such a luxury. Air conditioning units, which used to be almost non-existent in China, have expanded 55 times in the past decade. China produced just over 1,000 personal computers in 1985. Last year, 835,700 personal computers were sold!

Another *China Daily* article reported the advances in China's auto industry. During the past two years, 34 percent of the passenger cars and at least 95 percent of the 17 million motorcycles sold in China were bought by individuals. This is in stark contrast to the last 30 years when nearly all vehicles purchased in China were bought by governmental departments and state-owned offices.

A few short years ago, the only users of motor vehicles were government officials. Today, a wide number of cars are available for purchase and a growing number of Chinese "middle class" now own automobiles. Our local tourist guide in Xian told us that the most popular weekend activity for 25 to 45 year olds is to take a driver's education course and then get a drivers license (whether or not they can afford a car!).

A decade from now, the number of middle class people in China is estimated to be over 200 million people and all of them will want a car. In Ken Calder's excellent *Foreign Affairs* article, "Asia's Empty Tank", he observed that it would not be far fetched to envision 300 million cars in China at some future date. He might end up being too conservative in his observation.

China is clearly the most promising automobile market in the world. The Ministry of Machine Industries forecasts that total vehicle sales, including cars, vans and trucks, will grow from 1.6 million units in 1996 to 2.7 million by 2000 and to more than 6 million by 2010. Even with such high growth, though, China's automobile usage will still only be four vehicles per 100 people compared to current usage rates of 33 vehicles per 100 people in Taiwan, 52 per 100 people in the U.K. and 75 per 100 people in the U.S.!

It is also interesting to note what types of vehicles are being purchased in China today. Saloon car sales were up 30 percent last year and mini-vans and pickups are becoming more popular. The least popular are the compact cars where demand has been sluggish.

In Beijing alone there are now over 1.17 million cars, more than any other city in China. In 1985, there were only 260,000 cars. Beijing's current automobile demand is growing by 15 percent each year. However, Beijing still has 6 million bicycles, highlighting the potential magnitude of further automobile growth for just China's capital city.

There is also a rapid expansion in the use of motor bikes in many Chinese cities, though licenses are being controlled in some cities like Beijing due to worries of too much congestion until new highways are built. In 1996, China produced over 9 million motorcycles, making it the largest producer in the world. In the province of Guandong alone, 800,000 motorcycles were produced for domestic use last year. In 1997, over 1 million Guandong bikes will be produced. In the first quarter of 1997, motorcycle sales were up 88 percent from the same period in 1996.

In early 1997, another *China Daily* article commented on the surge in electrical appliance sales and noted that China is only years away from becoming the leading consumer of household appliances in the world. In China's larger cities, 92 percent of all households owned washing machines at the end of 1995, 89 percent had refrigerators and 17 percent had air conditioners.

In China's rural areas, only 16 percent have washing machines, less than 5 percent have refrigerators and there were almost no air conditioned homes. However, this also demonstrates the potential for explosive growth when rural areas begin to improve.

China's electricity demand has been growing by 8 percent per annum for the past 15 years. But, despite its enormous increase in electrical generation power capabilities, China still has less electricity than it needs. China's installed electricity generating capacity is only 0.18 kw per person compared to about 1 to 2 kw in most industrialized countries. Many cities suffer brown-outs, black-outs or limitations on the use of power during peak usage periods. Some estimate that current electrical shortages have reduced national production by as much as 20 percent. Based on its 9th and 10th five-year plans, China will increase its electrical generating capacity from 217 gigawatts today to 300 gigawatts in 2000 and 530 gigawatts in 2010.

Only a handful of high grade motorways existed a few years ago in any part of the country. In the early 1990s, a master plan to create a vast national highway network was unveiled. Since then, the program has expanded in both its scope and the pace of road construction.

By the time this national highway network is complete, 12 major highways (including first class expressways for the exclusive use of automobiles) at a total length of 35,000 kilometers will be built and will link all 30 provincial and autonomous regional capitals of China. Five are a north-south axis and seven are east-west axis.

The expansion of China's highway system will ultimately connect every Chinese city with a population of more than 1 million and 93 percent of the cities with a population greater than one-half million, which will benefit about 600 million Chinese.

About 4,000 kilometers of the national highways system has already been completed. At the end of 1996, China had 1.18 million kilometers of highways, but only 3,400 kilometers represented the new modern expressways. From my travels on a few of the already completed motorways, they are first rate systems and are comparable or better to what Houston enjoys. In magnitude, this is reminiscent of the highway era of the 1950s in the U.S. However, in terms of speed of construction, China beats us hands down.

As a key part of China's attack on reducing poverty, at least one highway is being built to reach every poor region so every state classified poor region has access to at least one road connecting to the national highways. This will enable agricultural and cottage industry products to be transported from these poor areas to other parts of the country.

As these road systems are completed, it is almost a certainty that car and truck usage in China will soar. This creates high growth for motor gasoline, along with the need for more natural gas if China succeeds in its plan to quickly introduce natural gas powered vehicles.

It is also remarkable to note how fast China has been able to build these new road systems. The Shanghai freeway system, for instance, was constructed in about two years. The new system is a ring road with an "X" through the circle. It is both modern and attractive. Accomplishing this two-year feat would be the equivalent of constructing Houston's 610 freeway system within Manhattan Island. As Houston has struggled to modernize its Gulf Freeway over the last 25 years, it provides a stark contrast to the speed at which modernization is taking place in China.

While air traffic still accounts for only 6 percent of China's total transportation needs, it has grown by 20 percent per year since 1978. The country has a large and relatively efficient commercial airline system with some 40 domestic airlines offering services to about 143 different cities. Last year, the country purchased 100 new airbuses. Between now and 2000, another 300 planes will be added. Ten new airports are underway in cities that have populations in excess of 5 million people and 30 existing airports will be upgraded during the next five years.

There are 500 other Chinese cities that have also applied for airports to be built over the next 10 years. Watch jet fuel consumption soar as these expansion plans come to pass.

China also has an extensive rail system. A new rail line was built from Hong Kong to Beijing in less than two years. The rail system is surprisingly efficient and inexpensive for the Chinese to use, though it is becoming strained since it also transports most of the country's coal needs. (Apparently over 70 percent of the rail system is used to transport coal around the country.)

China's major rivers historically inhibited the country's ability to effect trade between its various regions. Until 1949, for instance, there was no bridge across the Yangtzi River, which effectively divided North and South China. The first bridge was completed in 1949 and the second in 1969. Since 1978, 11 major new Yangtzi bridges have been built and an additional 13 are planned or are now under construction.

China's communications infrastructure is changing as rapidly as its transportation infrastructure. More than 15 million new state-of-the-art telephone connections were made last year and the growth in cellular phone usage has been astonishing.

The fax is perhaps the most important communications change in China since it allows people who speak different dialects to communicate long distance with ease for the first time.

China's state planners are also targeting big changes in the country's agricultural system through the use of fertilizers and automation, both of which intensify China's energy usage. As the agricultural system begins using modern tractors, this also frees up some of the rural "peasant" population to be employed in light industry. While fertilizer usage is just beginning to be employed, China is already the largest fertilizer consumer on earth. Much of the planned growth in more fertilizer use is expected to be supplied by natural gas.

When almost any aspect of China's economy is closely analyzed, the country seems to be doing almost everything right to insure a steady move up the ladder of economic change so its inherently talented people can soon enjoy the same lifestyle that every more advanced country in the world has enjoyed for years. But, to make all this happen China's energy will soar.

*The Successful Ingredients
For A Country to Grow*

Jeffrey Sachs, Professor of International Trade at Harvard University and Director of the Harvard Institute for International Development, published an article in *The Economist* on June 14, 1997 detailing the ideal characteristics that a country needs in order to prosper in today's global economy. These attributes came from a study the Harvard Institute for International Development undertook on patterns of global growth from 1965 through 1990.

The Harvard Institute for International Development study found that coastal countries grew faster than land-locked economies. Temperate zone countries grew faster than tropic zoned regions (although the use of air-conditioning is becoming a great equalizer in labor productivity for manufacturing and services).

A country's economic policy is also a particularly important development factor. Open economies have grown 1.2 percent faster each year than closed economies. Fast growing countries tend to have high savings rates and low spending relative to GDP. Finally, a strong "rule of law" almost always delivers growth.

Reducing high birth rates is another key to solid economic growth. Otherwise, there are always too many mouths to feed without a corresponding increase in the number of workers.

The Economist article noted that China already has many of these factors in its favor: it lies almost entirely in the temperate zone. Life expectancy is already about 70 years. China's main geographic problem is that hundreds of millions of peasants live in the interior, hundreds of miles from the coast. Moreover, infrastructure linking China's coast and its hinterland is grossly inadequate.

With these limitations in mind, the present course of China's development can be seen as far-sighted since the large government directed investments are heavily geared to building infrastructure aimed at transporting people and goods throughout all parts of China. When this massive investment program is finished, China will have eliminated its only serious drawback to Jeffrey Sach's model for a country's economic success.

The expansion of its highway and railway system, ambitious airport terminal construction and upgrade plans, improved navigation of the Yangtzi River along with the Three Gorges Dam combine to suddenly changing China from having an inadequate infrastructure to creating the world's most modern infrastructure system.

As in so many parts of China's economic master plan, all of these factors neatly mesh together to facilitate the fastest pace of economic advancement any major country has ever undergone. It seems likely that China's growth could easily match the pace of Japan between 1950 and 1970 or South Korea's advances between 1970 and 1990. A bigger question is whether China's economy can actually advance even faster.

China's Energy Supply

CHINA'S COAL AND THE ENVIRONMENT

China is now the largest consumer of coal in the world, fueled by having its energy demand more than double over the last decade and a half. Further expansion of China's economy will obviously lead to further growth in energy needs. However, predicting which of China's energy sources will benefit most from this growth is complex, particularly given China's unusual fuel mix.

As noted earlier, China now relies on its abundant coal resources for 77 percent of its energy. Petroleum makes up 20 percent with nuclear, natural gas and hydropower collectively make up the final 3 percent.

Since coal is such a major factor in meeting energy demand, it is not surprising that China is the world's largest coal producer. China also accounts for 30 percent of world coal consumption, despite its low per capita energy demand. China not only supplies all of its own coal needs, but also mines enough additional coal to export 28 million tons each year.

Most coal is mined in north and northeast China, which contain virtually all the large state-owned mines. Since the early 1980s, the central government has encouraged the development of small, individually or collectively owned coal mines in rural areas. This has started a significant shift in the structure of China's coal output. Between 1980 and 1993, 70 percent of the growth came from these now rural mines, but these gains are slowing due to mine safety and rational use of coal resource issues.

Based on the most recently available statistics, 44 percent of China's 1993 coal production came from its centrally administered state-owned mines, while local state-owned mines made up another 18 percent. Local township and village-owned mines made up 33 percent and privately-owned mines made up the final 5 percent.

China's rural mines are generally very small and are poorly equipped while the large state-owned mines suffer from under investment, partly due to low controlled coal prices before 1990 when investment in China's larger mines picked up again.

Investments in coal washing systems have been consistently overlooked, even though the many benefits including easing the burden on China's overloaded transportation systems and reduced emissions are well known.

China's heavy dependence on coal usage cannot continue. First, it is already experiencing logistical bottlenecks throughout the country. Few mining areas are close to the major consuming area: China's rail system is already clogged with trains laden with coal, which often account for over 70 percent of all Chinese rail movements.

A second far more serious problem is the impact coal is having on not only China's environment, but the environment of China's neighboring countries such as Korea and Japan.

Almost all of China's electricity is now generated by coal-based plants and few of these plants have any efficient form of gas desulphurization. According to the World Health Organization, six of the 10 most polluted cities in the world are in China. In parts of China, acid rain is so severe that crops are being affected. Further, rainwater with an acidity level equal to acetic acid has been observed.

Reputedly, one of the most polluted cities is Benxi in Manchuria which at times completely disappears from satellite photographs because of its sooty haze.

At its current consumption rate of 1.4 billion tons of coal per year, China is pouring an estimated 19 million tons of soot or total suspended particles (TSP) and 16.5 million tons of SO₂ into its air annually. To put this in perspective, its current rate of soot production created every three years equals the total weight of China's entire population!

In China's highly polluted major northern cities, the average concentration of suspended particle matter is 520 micrograms/M³. In China's major southern cities, the concentration is 318 micrograms. The World Health Organization safe health guidelines are 60 to 90 micrograms/M³.

With China's economy (and thus its energy needs) poised to continue expanding, these environmental problems could become worse. The Energy Research Institute of the State Planning Commission estimates the levels of sulfur dioxide and carbon dioxide could increase

by 60 percent and 80 percent respectively by 2010, if the present mix of energy sources remain unchanged.

China's coal-related environmental problems could be exacerbated even further as the country is forced to switch to a higher use of brown coal, which is located closer to the southeastern economic growth areas. However, this brown coal has a lower BTU content and much higher level of pollutants. To date, most of China's coal use has been supplied by cleaner burning coal from the northern regions where the sulfur content is typically under 1 percent. Since the rail system is running at full capacity, the country either needs to build expensive new transportation systems, build electrical generation capacity in the north which is then transported to the south or begin to use the much higher sulfur grown coal in the south of China.

To my surprise, and in stark contrast to the level of environmental awareness in most parts of the Former Soviet Union, China's current political and energy leaders seem remarkably attuned to and are highly concerned about their environmental problems. The problem they face is finding a feasible way to combat or reduce them.

From my discussions and a review of various published Chinese reports, there is a commendable degree of commitment to wean China from its extensive coal use and to improve the country's staggering environmental condition.

Until 20 to 30 years ago, coal was China's only source of energy. And, until 15 years ago, China had no money to pay for the expensive scrubbing devices, which only began to be used through the Western economies in the late 1960s and early 1970s. Furthermore, on a per capita basis, China does not even rank in the top 50 countries in terms of its greenhouse gas emission. According to the authors of *China Awakes*, every American is responsible for nine times as much greenhouse gas as the average Chinese citizen. China's environmental pollution is a function of the sheer size of the population rather than how much energy the average person consumes.

The fact is that China must use less coal as a percentage of its total energy needs. The question is what other energy alternative can become a realistic substitute for coal.

ALTERNATIVES TO COAL: CHINA'S OTHER ENERGY OPTIONS

The largest project associated with reducing China's coal usage is the Three Gorges Dam development. This will cost over \$27 billion and will be the world's largest hydropower project once it is completed in 2009. The Three Gorges Dam involves a series of dams on the Yangtzi River creating a man-made lake 660 km long. The project will ultimately have a capacity of 18,200 megawatts and will reduce coal consumption by approximately 40 million tons annually. (This, however, only cuts China's coal use by 3 percent per year, at a cost of \$9 billion for each percentage point of reduction!)

This giant energy project has created considerable controversy among conservationists since it not only covers some of the most beautiful river canyons in the world but will displace over 1 million people. These objections miss some of the major benefits of the Three Gorges Dam. In addition to delivering a vitally needed source of electricity, it also eliminates the floods that have regularly caused havoc in this region for centuries. Thus, it ensures the safety of 15 million people and 1.5 million hector of farmland. It also improves the mid and upper levels of the Yangtzi River system, thus increasing the total barge capacity five-fold while reducing transportation costs by nearly one-third.

The sheer scale and expense of the Three Gorges Dam for such a small increment of annual energy supply suggests that hydropower generation will not be the answer to China's energy problem.

China is expanding its nuclear capability as fast as it can, adding three to four new plants over the next several years. By 2005, when these plants are complete, nuclear generation will reach 20,000 mw, making nuclear power China's third most important fuel. Even so, nuclear will still only account for 3 percent of China's electricity generating capacity and less than 1 percent of its total energy needs.

Nuclear plants take almost a decade to build, and the four currently under construction are the only planned plants. It is clear, therefore, that nuclear power will not materially impact China's real energy requirements for at least the next decade. It must be said, however, that nuclear power presents an attractive long-term option for China despite the cost and long lead time involved.

CHINA'S SLEEPING TIGER: NATURAL GAS

The most significant initiative to reduce China's dependence on coal is the exploitation of its "sleeping tiger" - natural gas. The country plans to aggressively develop its natural gas resources and construct the gigantic infrastructure required to import natural gas and NGL.

China is believed to have an abundant amount of indigenous natural gas. It only produces about 6 bcf per day, which accounts for 2 percent of China's current energy needs. Since the country has never had a gas transportation infrastructure, it has never aggressively drilled even in its already discovered gas reserves. According to the country's Planning Commission, China's natural gas demand will grow more than five-fold by 2015, bringing its natural gas consumption to over one-half of the current U.S. daily consumption. The use of natural gas to produce fertilizer and petrochemicals will be supplemented by the planned use of vehicles using compressed natural gas rather than petroleum.

The country's major gas reserves are located in its Sichuan province, Bohai Bay, the South China Sea and in the western regions of the country. Expanded exploration and development is planned for all of these areas.

China also plans to construct LNG terminals along its southern coastal region so it can import LNG from the Middle East and elsewhere in Southeast Asia.

China has several major natural gas pipeline projects either under construction or in the planning process. The first natural gas pipeline runs 850 km from Sichuan to Beijing and will be completed in October 1997 at a cost of \$470 million. This will bring the first natural gas to Beijing. In preparation, a pipeline ring already circles Beijing. China's National Petroleum Corporation ("CNPC") is actively marketing the use of natural gas to industrial and commercial users in the Beijing area. (Many of these potential new natural gas consumers are apparently uneasy and uncertain as to how this "flame" energy source really works, a reaction not dissimilar to that of new U.S. users of natural gas 40 years ago!)

The new natural gas supply to Beijing will enable 100,000 households that currently use coal to now use clean burning natural gas. By 2000, more than 1 million families will be natural gas users with 850 million cubic meters of gas each year replacing coal. However, based on

Beijing's current population, the city would need 3 billion cubic meters of natural gas each year to replace all the coal burned within the Third Ring Road around the city. When the Russian gas pipeline mentioned below is finished in 2005, this will hopefully become a reality.

The city of Tianjin, with 9 million residents, will also benefit from the new Shaanxi pipeline since 100,000 households will begin using natural gas this fall. Four years later, the volume of natural gas introduced to the city will increase to 400 million cubic meters per year.

The 2005 Russian pipeline is one of two being planned to bring natural gas from Siberia to China. The other, which will hopefully be in operation in 2002, will bring Sakhalin Island gas down through China's northeast region to the Shenyang area. The length of the pipeline is 1,810 km from Sakhalin to China's Harbin area.

The other Russian pipeline, which will hopefully bring even more Russian gas to China, will begin in the Irkutsk region of Western Siberia and end in the booming Shandong Province on the Yellow Sea. The project is now in its pre-feasibility phase and was the subject of one of the major initiatives signed by Premier Li Peng and his Russian counterpart, Mr. Chernomyrdin, in late June 1997. The pipeline is expected to be operational by 2005. This line is 3,364 km in length with 60 percent located inside Russia's borders. The estimated cost totals \$7 billion. At peak capacity, the pipeline should deliver 20 to 25 billion cubic meters of gas per year to China.

Another possible long-term future source of natural gas is a subsea pipeline that would run from Indonesia to northeast China, probably coming onshore at China's southern border. But, the project with the largest impact to deliver massive amounts of natural gas to China is a natural gas pipeline that would deliver Central Asian natural gas to China. This project is often called the "Project of a Century" and will ultimately bring natural gas supplies from Turkmenistan and other parts of Central Asia as well as China's Tarim Basin to eastern China and possibly Japan. The pipeline will be 8,000 km long and will cost over \$22 billion to construct.

It will cost over \$12 billion just to bring the gas to the coastal region of China. Another \$10 billion of investment is needed to take the natural gas underwater to Japan. However, given China's enormous needs, the final \$10 billion might never be spent since all this supply could easily be consumed by China alone over the next 10 to 20 years. The partners in this project are Mitsubishi, Exxon and CNPC.

The Chinese are very bullish about the country's natural gas resources, even though there has been relatively little gas drilling. Hopefully this optimism will be borne out by exploration successes. It would be a tragic blow to the country's strong desire to wean itself from coal if gas drilling turned out to be as disappointing as it has been in finding new sources of oil in both the Tarim Basin and the East and South China Seas.

Even if China's officials prove correct in their optimistic assessment of its ability to exploit ingenious natural gas resources, imported gas will still be required since China's overall needs would be so great if coal usage was ever significantly reduced.

From a strict environmental standpoint, it is critical to both China and its neighboring countries that they succeed in its objective of using massive quantities of natural gas. This "sleeping tiger" needs to awake.

CHINA'S OIL RESOURCES

The final and perhaps most important part of China's energy equation is its oil resources. These, of course, are used to produce motor gasoline, diesel, jet fuel, heating oil and provide petrochemical feed stock. While China's petroleum consumption provides only one-fourth of the energy produced from coal, it equals four times that provided by nuclear, natural gas and hydropower combined.

China became a world class oil player about 40 years ago and is the fifth or sixth largest oil producer in the world, depending on Norway's oil production at any given time. It was also an important oil exporter for two decades until it finally became a serious importer three years ago.

China's oil dilemma is that oil demand is now expanding far beyond its ability to increase daily oil supply. China's oil supply has little prospect of growing quickly. Moreover, its existing production base is now beginning to experience normal depletion. Only massive development drilling and enhanced oil recovery projects will enable China to keep its current base stable.

CHINA'S ONSHORE OIL

Essentially all of China's onshore oil resources are owned by CNPC, which in terms of its daily oil production rivals companies like Mexico's state oil company, Pemex, or Venezuela's PDVSA in size. All three are larger than either Royal Dutch Shell or Exxon.

CNPC was formerly the Ministry of Petroleum Industry. It is now a corporate entity with a mission to explore, develop and produce all of China's onshore oil and gas including islands surrounding China and offshore to a depth of 5 meters. CNPC has 21 large and medium-sized oil and gas production bases located around China. As is the case for the Russian Production Associations, many of these "production bases" are large towns or even cities and CNPC is often responsible for providing most municipality functions as well.

CNPC has nearly 400,000 technical specialists and operates 274 scientific research institutes, it has 14,000 sets of large scale scientific research instruments and operates nine universities for developing petroleum personnel. In various oil regions, CNPC in itself essentially runs the city. In total, CNPC employs almost 1.75 million people. By any standard, CNPC is a large enterprise.

While China describes each of its major oil and gas reserve units as "fields", they are really major basins with some covering vast areas. About 70 percent of China's current oil production comes from four large basins that were discovered 30 to 40 years ago. Each clearly qualifies as being a mature field. The average water to oil cuts in these fields range between 80 and 90 percent.

China's largest producing basin is its Daqing Field, which actually includes 20 individual fields, three of which account for 90 percent of Daqing's total daily output. This field, China's only super giant, was discovered in 1959. The Daqing Field has produced a steady 1 million barrels per day since 1976. Its largest single production unit is its Sartu Field, which currently has a water to oil cut of 97.5 percent! Enhanced recovery plans were recently announced to keep Daqing's production at this 1 million barrel per day rate through 2010, but it requires an investment of almost \$20 billion.

Shengli is China's second largest oil supplier. This field produced 616,000 barrels per day in 1996. Shengli was discovered in the late 1950s and began producing in 1964. Its output comes from 59 individual oil and gas fields. Shengli peaked several years ago at a production rate close to 700,000 barrels per a day, but parts of the field are also starting to encounter early stages of high water cuts.

China's Liaohe Field was discovered in 1960 and began production in 1970. It is now China's third largest field, producing about 300,000 barrels per day. Two-thirds of China's heavy oil is produced by Liaohe, which is comprised of 22 individual fields. In 1982, a steam injection program was started to boost output of this heavy oil.

As China's major onshore fields began to mature and started experiencing ever increasing water cuts, CNPC was still able to maintain steady or even slightly increasing oil production through aggressively drilling more infill wells and using advanced oil recovery techniques. However, these efforts were only aimed at keeping production stable.

For the past decade or more, China's efforts to significantly increase domestic oil production was directed towards two new initiatives. First was successful offshore oil development, which was the more brief of the offshore sister company to CNPC, the Chinese National Offshore Oil Corporation ("CNOOC"). Second, and more important, was the exploitation of China's oil bearing basins in the remote western parts of China: the Tarim and Junggar Basins.

Serious exploration efforts commenced in both of these western basins over a decade ago and China's hope was that reserves would rival the giant fields of the Persian Gulf or Western Siberia.

CNPC finally opened these western China regions to foreign oil and gas explorers and by the end of 1996, nearly 1 million square miles of onshore areas had been licensed with revenue exceeding \$700 million from signing contracts and commitments.

However, drilling conditions were tough and the geological formations very complex. To date, the experiences of foreign oil companies exploring in the Tarim Basin have not been encouraging. Initially, many thought this was only because China kept its best acreage for itself, as Chinese oil officials still claim that this area could contain over 80 billion barrels of oil

and 350 trillion cubic feet of natural gas. But, CNPC's own efforts have also yielded only small amounts of oil production. Hopes are still high that extensive drilling will some day unlock the vast hydrocarbon potential that this region is hoped to possess. New exploration initiatives are still being pursued by both CNPC and new foreign licenses.

The real long-term potential of China's Tarim and Junggar Basins will only be known after years of additional exploration. But so far, less than 4 billion barrels of oil reserves have been verified and 1997 peak oil production is estimated to hit only 88,000 barrels per day, which is just 25,000 barrels per day over 1996 production levels and a far lower production rate than could justify building a pipeline since the transportation distances are very large.

Active exploration efforts continue in these western regions of China and throughout the rest of the country. There are currently 27 seismic crews and 46 drilling crews active in the Tarim Basin. CNPC operates 380 land drilling crews while the Ministry of Geology operates 50 exploratory rigs of China's onshore-based exploration and development efforts.

CNPC recently launched an intensive effort to revitalize oil and gas production from its Changing Field, which was initially discovered in 1903 but had been neglected for a long time due to difficult geologic conditions. An extensive seismic study of the field has been completed and CNPC now estimates that the huge basin, covering 370,000 square kilometers, might contain over 15 billion barrels of reserves. To date, only one-quarter of the field has been explored and 100 drilling crews have been organized to exploit this basin.

Over the past five years, CNPC has drilled about 9,500 wells per year, or roughly similar to Canada's oil and gas development efforts. Approximately 900 of these wells are exploratory and the balance are development wells.

CHINA'S OFFSHORE OIL AND GAS

China's offshore oil production is the responsibility of CNOOC, which was split off from CNPC in 1982. CNOOC has been actively exploring its offshore prospects ever since and has been overseeing an aggressive licensing program of its offshore acreage. Twelve major offshore fields and seven smaller offshore fields are now in production and another 10 fields are expected to be onstream by 2000.

China's offshore production has grown steadily, exceeding 168,000 barrels per day in 1996 with 1997 targeted at almost 300,000 barrels per day. However, this will still only be about 10 percent of China's total production. By the end of the first decade of 2000, CNOOC hopes to have about 400,000 barrels per day of offshore oil production and another 10 billion cubic meters of offshore natural gas. (Offshore natural gas production in 1996 was only 3 billion cubic meters.)

CNOOC has signed almost 100 contracts with foreign oil companies in its four offshore regions: the South China Sea accounts for 43 percent of the foreign licensed acreage; the East China Sea accounts for 36 percent, the Bohai Basin accounts for 19 percent, and the Beigu Basin accounts for the final 2 percent.

China drills about 50 offshore wells each year. In 1995, 39 offshore wells were drilled for exploration. Of these, 25 were wildcat wells and 14 were appraisal wells. Of these 39 wells, 20 were drilled by foreign companies and unfortunately, 18 were dry holes. CNOOC, on the other hand, drilled eight wildcat wells and 11 appraisal wells. Interestingly, all four of CNOOC's 1995 commercial discoveries came from acreage previously surrendered by foreign operators. This would seem to dispel the myth that China keeps all the attractive exploration acreage for itself.

CNOOC has a relatively modern fleet of offshore rigs. It owns and operates nine jack-up rigs and three semi-submersible rigs.

Supporting CNOOC's 12 offshore rigs are 10 CNOOC-owned oil service companies. China Offshore Oil Geophysical Co. has five survey vessels, four subsea cable vessels, three seafloor geology investigating vessels and one supply vessel. China Oil Logging Co. provides logging to both offshore and onshore oil and gas wells. China Offshore Oil Technical Service Co. provides

directional drilling, MWD equipment and mud testing services. Two separate supply boat companies own and operate 43 anchor handling/tug/supply vessels.

From time to time, these rigs and support services have operated in other parts of the world, proving they are world class in their capabilities. CNOOC has recently announced that its offshore oilfield services group will soon be listed on a local exchange so it can tap capital to expand and modernize its fleet.

CHINA'S EXPANSION INTO INTERNATIONAL E&P

By the early 1990s, China's central government began to realize that its demand for crude oil would rise rapidly following high economic growth rates that were expected to extend into the next century. It became clear that domestic reserves alone would not be sufficient to meet this demand. Both CNPC and CNOOC were encouraged by the Chinese government to expand aggressively into foreign areas of production. Both units are now actively pursuing these initiatives.

A limited expansion had already begun in countries like Peru, Canada and Indonesia, but even many Chinese insiders, according to a *Chinese Business Weekly* article published in late April 1997, openly question whether either CNPC or CNOOC have had sufficient imagination or were flexible enough regimes to really grasp business opportunities abroad.

In the month of June 1997, CNPC responded to these critics by announcing four major investments totaling almost \$20 billion. First came a \$4.3 billion investment in Kazakhstan for a 60 percent stake in its main oil company and a pledge to build a 1,800 kilometer crude oil pipeline from Central Asia to China at a cost of another \$3.5 billion. Hours later, it signed a \$1.2 billion agreement with Iraq to develop and operate the al-Ahdab 90,000 barrel oil field. Within another week, CNPC bid over \$300 million for two tracts in Venezuela. Finally, at the end of a busy month, China signed a \$10 billion pact with the Russians to supply both oil and natural gas from Siberia. In late July 1997, CNPC beat out strong competition by Amoco and UNOCAL to develop Kazakhstan's Uzen oilfield, located on the last Caspian Sea Coast which is estimated to hold 130 to 200 million tons of oil. Once again, CNPC opened its massive checkbook and agreed to invest \$1 billion to modernize this field. It seems likely that the trend of CNPC "investing abroad" is just beginning. So much for the skeptic's view that the Chinese lack the ability to grasp foreign opportunities!

CNPC has already stated that it aims to produce between 100,000 and 200,000 barrels per day outside China by the year 2000, increasing to 300,000 to 400,000 barrels per day by 2010. This could be just the tip of an iceberg though if CNPC has a few more months were the company is as active as it has been in the summer of 1997.

The U.S. oil service industry needs to pay close attention to these aggressive moves. Over the next few years, CNPC and CNOOC could surpass Shell, Chevron, Exxon or Texaco as the world's biggest purchaser of oilfield services.

***Projecting China's Future
Energy Needs***

Since so many factors point to a continuation or even an acceleration in China's economic growth, the question quickly shifts from whether its past energy growth can be sustained to how large China's total energy needs could actually be. An even bigger question is whether the country can manage this growth in its energy demand while also trying to wean itself from "dirty coal".

Over the past decade, China's energy demand was growing at about 70 percent the rate of China's economy. However, this statistic might be meaningless since there were several years when energy growth significantly exceeded economic growth and other years when government restrictions on oil imports artificially held down energy demand.

I am hesitant to draw any meaningful conclusions about China's future energy needs from the historical relationship between China's economic growth and its energy group. When the disparity between China's officially recorded GDP and the same GDP when adjusted for purchasing power parity, the historical "economy-to-energy" relations become even less relevant.

But, in assessing China's future energy needs, there are a few givens. First, China's automobile use must rise since the country's rapidly expanding highway system will ultimately be used. In the meantime, motorcycles will replace a significant portion of the enormous bicycle usage in China over time because both vehicles take the same amount of road space and one is far more efficient to transport human beings than the other. Finally, as China's economy improves, its people will want to create the same type of personal lifestyle that is now enjoyed in Taiwan, Hong Kong and Singapore. As all these changes happen, oil and gas demand must soar. The two go hand-in-hand.

Only 20 years ago, even most educated Chinese genuinely believed that their lifestyles were possibly superior to the average lifestyle in the Western World. Today, virtually everyone throughout China knows this was a gigantic myth. Even former peasants in parts of rural China can now observe Western lifestyles through their television sets.

As these lifestyle changes occur, energy consumption will climb. China's big energy question is not whether growth will occur but how much energy demand will be generated by the economic revolution that is gathering steam.

IS THE PAST A CLUE TO THE FUTURE?

One way to start growing the magnitude of China's future energy growth is to simply measure the historical change that has occurred in various other countries which have undergone similar periods of significant economic change.

Start with the United States. As the original developer of automobiles, which ushered in the age of oil, our country became a major oil consumer by the 1920s. Then, in the 1950s, Eisenhower engineered the "freeway era" for the U.S., which encouraged the development of the American suburban move. Between 1950 and 1970, U.S. per capita oil demand grew from just under 16 barrels per person each year to over 26 barrels per person. (Table 4 details this change.)

Japan offers another model of how rapidly oil demand can rise when an economy enters a period of growth. In 1960, Japan's oil consumption was only 2.6 barrels per person each year (which was two and one-half times greater per capita consumption than China has today). By 1970, oil demand increased five-fold. A decade later, per capita oil demand was 15.5 barrels per person each year, nearly a seven-fold growth in only 20 years. (Table 5 shows Japan's rise in petroleum demand as it changed into an industrial power from 1960 onward.)

Table 4
Impact Of United States Freeway Building Era

	<u>Petroleum Demand</u> (MMB/D)	<u>U.S. Population</u> (Millions)	<u>Per Capita Consumption</u> (Annual BBL/Person)
1950	6,500	150.7	15.8
1960	9,700	179.3	19.7
1970	14,700	203.2	26.4

Table 5
Japan's Growth In Oil Demand

	Petroleum Demand (MMB/D)	Japan's Population (Millions)	Per Capita Consumption (Annual BBL/Person)
1960	700	93.6	2.6
1970	3,800	103.5	13.5
1980	5,000	111.8	15.5

South Korea offers an even more recent example of how fast an underdeveloped country can change in today's high technology, globally economy-oriented world. In 1970, Korea's per capita oil demand was only 1.9 barrels per person each year. Over the next 15 years, per capita oil demand more than doubled to 4.5 barrels. Five years later it doubled again and by 1994, Korea's per capita demand was 14 barrels per person.

Interestingly, Taiwan's growth in oil demand followed an almost identical path as that of South Korea, as demand of 60,000 barrels per day in 1970 (or 1.6 barrels per person) grew to 665,000 barrels per day (or almost 12 barrels per person) in 1994. Other examples of how fast per capita oil demand can rise are found in countries like Spain, Portugal, Greece and Turkey. While all had increases of a less dramatic proportion than South Korea or Taiwan, all experienced quantum leaps in per capita oil consumption as their economies improved.

Table 6 details the oil consumption changes from a variety of developing countries between 1970 and 1994. The usage pattern in every country underlines the unstoppable relationship between rapid economic change and the increased use of energy.

Table 6
Sampling Changes In Country Oil Consumption

Country	Thousand Barrels Per Day		Population (Millions)		Per Capita Demand	
	1970	1994	1970	1994	1970	1994
CHINA	560	3,181	745.0	1,190.0	0.3	1.0
South Korea	165	1,073	31.0	44.4	1.9	14.0
Spain	565	1,170	33.0	39.1	6.2	10.4
Portugal	95	270	9.7	9.9	3.6	10.0
Greece	135	345	9.0	10.4	5.4	12.2
Turkey	155	540	34.8	60.8	1.6	3.2
Taiwan	60	665	13.9	21.0	1.6	11.6

While these are examples of relevant proxies for China's future energy needs, they might be understated because China's economic growth could outpace every other example. None of these other countries had such a combination of powerful forces propelling its growth that is now happening in China.

At the least, China's economy is poised to continue the growth it has now experienced for the past 15 years, but it could grow even faster. Therefore, China's recent strong growth in energy demand will continue or accelerate. Guessing the general direction of China's energy needs is easy. Trying to predict its future growth rate with any degree of precision is far more difficult.

THE CONVENTIONAL WISDOM GROWTH MODELS

It is interesting to examine the variety of published forecasts for China's future oil and gas demand over the next five to 20 years. Table 7 lists six published forecasts. Shell China and China's State Planning Committee have the two most optimistic predictions. Both forecast Chinese oil consumption will rise to 10 million barrels per day in 2015. The Chinese State Planning model estimates that oil demand will rise from approximately 3.3 million barrels per day in 1996 to 6 million barrels per day in 2010. The East/West Center estimates that China will be importing 2 million barrels of crude and finished products by 2005, accounting for 38 percent of its total oil needs, which implies a total demand of 5.3 million barrels per day by then. All six forecasts use growth rates ranging from 4.9 to 6 percent per annum for China's oil demand over the next decade or two.

Table 7
Sample Of Chinese Oil Demand Forecasts
(Million Barrels Per Day)

Source Of Forecast	2000	2005	2010	2015	Compound Rate Of Change
EIA	4.4	5.5	6.9	8.6	5.2%
East/West Center	N/A	5.3	N/A	N/A	5.5
Hydrocarbon Asia	4.03	5.0	N/A	N/A	4.9
Petroconsultants	N/A	5.50	N/A	N/A	5.9
China State Planning	4.0	N/A	6.0	10.0	6.0
Shell China	N/A	N/A	N/A	10.0	6.0

China's most recent forecast for its natural gas demand projects a rise from 2.5 bcf per day in 1995 to 4.3 bcf in 2000 to 6.7 bcf per day in 2005 and 12.9 bcf per day in 2015, an increase of more than five-fold in 20 years. This is strong growth, but it still leaves China's natural gas consumption in 2015 at one-fifth of what the U.S. consumes today.

Because the jump in volume of oil and gas needed is large, these forecasts have the appearance of being aggressive. However, every forecast also implies that China's total hydrocarbon demand, on a per capita basis, will always remain far below that of almost all other

emerging economies of the world. For instance, assume that Shell China's forecast of 10 million barrels per day in 2015 really happens, you must also calculate the impact of China's population growth by 1.5 percent per annum over this same period of time. China's per capita demand would have only increased to 2.3 barrels per person over the next 19 years. This is only slightly higher than what South Korea, Turkey or Taiwan consumed in 1970 and only 60 percent of what Thailand consumes today. At this low level of growth, China's overall economic expansion would almost certainly grind to a halt.

Another way of putting into perspective a future oil consumption of only 2.3 barrels per day is to examine countries like Colombia, Poland, Algeria, Egypt and Turkey. All attained per capita oil consumption rates of 2 ½ to 3 barrels of oil per person by 1994 and each of these country's economies are "just beginning to emerge".

While some rural parts of China could maintain a low per capita petroleum demand 10 to 20 years from now, it is enlightening to see how different petroleum consumption is today between the various regions of China (Table 8). Note that the northeast region of China, with a population of 108 million people in 1995, already consumes 2.3 barrels of oil per person each year. Three of the other large population centers of China in 1995 also consumed over 1 barrel of oil in 1995: the north region with 327 million people, the Lower Yangtzi with 194 million people and the South with 193 million people. When added together, the population of these four regions equaled 785 million people who consumed 2,660,000 barrels of oil each day, or a total of 1.24 barrels per person each year.

Table 8
Chinese Oil Regional 1995 Consumption

<u>Region</u>	<u>Population</u> (Millions)	<u>Oil</u> <u>Consumption</u> (BBL/Day)	<u>Per Capita</u> <u>Oil</u> <u>Consumption</u>
CHINA (Total)	1,238	3,270	0.9
Northeast	108	677	2.3
North	327	867	1.0
Mid-Yangtzi	167	258	0.6
Lower Yangtzi	194	674	1.3
South	156	448	1.1
Southwest	193	101	0.2
Northwest	66	118	0.7
West	24	121	1.8

THE PLATFORM ECONOMIES: HONG KONG, SINGAPORE AND TAIWAN

Another “role model” for the growth in Chinese oil demand for the populous coastal region of China are the so called three “platform economies” which surround China. All three are dominated by the Overseas Chinese. These are Hong Kong, Taiwan and Singapore. Collectively, these three countries have a population of 31 million people. In 1994, their combined per capita energy consumption was 27 barrels per person in 1994. In just three years, it has risen to an estimated 30 barrels. While falling short of U.S. levels, per capita energy consumption is already equal to Japan or most of Europe.

Note, however, that these per capita numbers are for total energy consumption, not just oil and gas. Like China, these three countries also primarily consume coal. Oil only makes up 21 percent of their total energy bill, but this still translates into an oil demand of 505,000 million barrels per day from these 31 million people, or almost 6 barrels of oil equivalent per person each year.

If the same per capita oil consumption of Hong Kong, Singapore and Taiwan is applied to the three largest coastal cities of China: Shanghai, Beijing and Tianjin, with a combined population of 34 million people, they would collectively consume over 550,000 barrels of oil per day or close to 15 percent of China’s total current demand.

If the 780 million people living in China’s most prosperous eastern third of the country were to generate a similar rate of oil demand to the three platform economies, China would need almost 13 million barrels of additional oil per day. If the rest of China’s population only consumed 1 barrel per person of oil each year and the coastal population and the remainder of China grew by 1 percent per annum, China would need almost 18 million barrels per day of oil by 2012.

THE IMPACT OF CHINA CHANGING ITS FUEL MIX

It is clear that China is serious about weaning itself from its heavy use of coal. The detrimental effect of its coal mix is already too well recognized for this problem to be ignored. Neither hydropower nor nuclear will realistically make a dent in China's ability to substitute other forms of energy for its current coal needs in any meaningful time frame. Thus, oil and gas are China's only practical alternatives to wean itself from coal.

I have developed three models to project China's possible future energy needs. Any of the three are plausible possibilities and illustrate China's enormous future energy needs. Case One assumes that China's energy demand over the next 10 to 20 years continues to expand at the rate of the past decade - 4.3 percent per annum. Case Two assumes that China reflects Taiwan's experience over the past decade - 7 percent per annum. Case Three is based on South Korea's growth in energy demand from 1985 through 1995 - 11 percent per year.

Case One implies a total growth in energy demand, on a barrels of oil equivalent ("BOE") basis, from 16.7 million barrels of oil equivalent in 1995 to 38.7 million barrels in 2015. Case Two, the Taiwan model, creates a growth to 64.5 million barrels of oil equivalent by 2015, while Case Three, the South Korea model creates a need for 134.3 million barrels of oil equivalent (Table 9).

Table 9
China's Energy Needs
The Pressure From Changing Fuel Mix

Assumptions

Case One: Continuation Of 4.3 percent Compound Energy Growth
Case Two: Taiwan's Last Decade Of Growth (7 percent Per Annum)
Case Three: South Korea's Growth (11 percent Per Annum)

<u>Total Energy Consumption</u>	<u>Barrels Per Day Of Oil Equivalent</u>		
	<u>1995</u>	<u>2005</u>	<u>2015</u>
Case One	16,662	25,388	38,679
Case Two	16,662	32,776	64,475
Case Three	16,662	47,310	134,334

If China does not begin this weaning process, in the low case model China's coal use jumps from 1.2 billion tons per year to 2.8 billion tons in 2015. In the high case, its coal usage jumps eight times to almost 10 billion tons of coal each year. From an environmental standpoint, even the low case is unacceptable. This massive increase in coal use, even if coupled with the use of the most technically advanced coal scrubbing equipment, still results in pollution emissions of vast and unprecedented proportions.

As these coal consumption rates are unacceptable, Table 10 shows the impact on both China's coal consumption and the rapid rise in all of China's other energy sources as the country begins the weaning process from coal. The same three model growth scenarios have been used, but in all three cases China's coal use drops from 77 percent in 1995 to 65 percent in 2005 and 60 percent in 2015.

I arbitrarily assumed that coal as a percent of total energy dropped from 77 percent in 1995 to 65 percent in 2005 and 60 percent in 2015. I then used the same three models already described. (Case One: China continues its historical climb. Case Two: China becomes Taiwan. Case Three: China becomes South Korea.)

Table 10 China's Energy Needs The Pressure Of Changing Fuel Mix

Case One: 4.3 percent Compound Energy Growth (Same As Past Decade)

Case Two: 7 percent Compound Energy Growth (Taiwan's Past Decade)

Case Three: 11 percent Compound Energy Growth (South Korea's Past Decade)

Fuel Mix		1995	2005	2015	2015
Coal		77%	65%	60%	Per Capita Usage (1.5% Population Growth = 1,606.3 Billion)
Oil		19	25	26	
Natural Gas		2	6	10	
Other		2	4	4	
		BOE/Day Usage			
Case One	Coal	12,830	16,500	23,207	5.3 BOE/Person
	Oil	3,166	6,346	10,057	2.3
	Natural Gas	333	1,523	3,867	0.9
	Other	333	508	774	0.2
Case Two	Coal	12,830	21,304	38,685	8.8
	Oil	3,166	8,194	16,764	3.8
	Natural Gas	333	1,967	6,447	1.5
	Other	333	655	1,290	0.3
Case Three	Coal	12,830	30,750	80,600	18.3
	Oil	3,166	11,828	34,927	7.9
	Natural Gas	333	2,839	13,433	3.1
	Other	333	946	2,687	0.6

Source of current data: BP Yearly Statistics.

What each of these three cases highlight is the urgency for China to wean itself from such high coal usage. The problem embedded in each is how rapidly the hydrocarbon energy sources must grow to make any significant change in China's fuel mix.

By dropping coal use from 77 percent to 60 percent, China's other forms of energy need to collectively increase their percentage by 17 percent of an already rapidly growing pie. I have arbitrarily assumed that oil use grows from 19 percent in 1995, to 25 percent in 2005 and 25 percent in 2015 while natural gas use grows from 2 percent in 1995, to 6 percent in 2005 and 10 percent in 2015. Even though these changes are significant, China's coal consumption still nearly doubles even under Case One, the model that envisions China's energy growth merely stays at the pace experienced in the past decade and does not accelerate. In Case One and this shift in China's fuel mix, oil demand jumps by three-fold, slightly exceeding Shell China's most aggressive future forecast. Natural gas demand must grow by almost 12-fold. But, this low case also leaves China's per capita oil usage at unrealistically low levels of only 2.3 barrels per person each year in 2015, making this model could easily be an unlikely scenario.

Case Three, the South Korea model, is close to the rate of energy growth that China has actually experienced in several of the last few years. Using this to project forward coal consumption creates a jump of 6.3 times even though the fuel mix drops to 60 percent. In the meantime, oil demand needs to grow 10-fold and natural gas demand must expand by 40-fold in only 20 years.

As astonishing as these figures are, a 40-fold increase in China's natural gas demand, divided by China's probable population in 2015, still leaves the country with only a 3.1 barrels of oil equivalent (BOE) per person demand. This is only 70 percent of Malaysia's current natural gas consumption and 20 percent of United States per capita gas use.

While Case Three is not a "most likely" forecast, it is certainly not out of the realm of reality. What is frightening about Case Three is the prospect that China's coal consumption would increase by over six-fold to over 7 billion tons per year. This not only represents an ecological nightmare for China, but probably for the remainder of the globe as well. In the midst of such staggering increases, the greenhouse debate would likely switch to a hot-house phobia. The prospect of an environmental war to stop this global environmental threat is not farfetched.

In fact, from a purely environmental perspective, China's coal use becomes unacceptable under any of these three models. The only scenario involving coal that makes ecological sense is to drop China's coal use from 77 percent to the current worldwide average mix of 27 percent.

By making China's other energy sources mirror the rest of the world, oil would supply 40 percent of China's energy needs, natural gas would contribute 23 percent and "Other", which is primarily nuclear and hydropower, would total the final 10 percent of Chinese energy supplies. Table 11 details the impact of switching China's fuel mix to the worldwide averages.

Table 11
Changing China's Fuel Mix To World Averages

	1995 Current Mix	2015 Target Worldwide Average Mix
Coal	77%	27%
Oil	19	40
Natural Gas	2	23
Other	2	10
	<hr/> BOE/Day <hr/>	
<u>Case One</u>		
Coal	12,830	10,443
Oil	3,166	15,471
Natural Gas	333	8,896
Other	333	3,867
<u>Case Three</u>		
Coal	12,836	36,270
Oil	3,166	53,734
Natural Gas	333	30,897
Other	333	13,434

By using this “worldwide average fuel mix” target, China’s future coal consumption actually falls by 18.6 percent over the next 20 years in Case One. But in Case Three, China’s coal use still almost triples to over 36 million barrels of oil equivalent per day.

While this is a far more tolerable projection for China’s coal use, it places overwhelming pressure on oil and natural gas and creates the need for massive growth in all other sources of energy.

In Case One, China’s oil demand jumps from 3.2 million barrels per day to 15.5 million barrels in 2015. In Case Three, China’s oil requirements rise to a staggering 53.7 million barrels per day in 2015. Natural gas needs are even more severe since as this environmentally friendly fuel source must increase from only 2 percent to 23 percent of energy supply in less than 20 years.

In total volumes, China’s daily natural gas requirements jump from 333,000 barrels of oil equivalent in 1995 to 8.9 million barrels of oil equivalent per day in 2015 in Case One and almost 31 million barrels of oil equivalent per day in Case Three.

Finally, we should note that “Other Energy Sources” must increase almost 12 times in Case One and 40 times in Case Three. This implies not only a lot of additional nuclear plants and major hydropower projects, but an aggressive use of all other energy sources from solar panels to windmills to geothermal energy.

Admittedly, the numbers produced from my Case Three along with an intense weaning from coal are probably logistically and physically impossible for China to achieve by 2015, even with help from throughout the world. But, as staggering as these numbers are in volume of oil and gas consumed, they still leave China using only 12 barrels of oil per person in 2015, (a rate equal to Greece today) and natural gas use only totals 7 barrels of oil equivalent per person.

While numbers of these magnitudes are probably impossible to achieve by 2015, thus preventing China from achieving such massive “coal weaning” and/or also forcing its economic growth to slow, the numbers could be achieved in another 15 or 20 years pointing to a need for steady increases in the world’s supply of oil and gas for most of the first half of our next century.

***What The World And China
Need To Do Next***

INTRODUCTION

Unless the miracle of China suddenly fizzles, China needs to bring on more new energy supplies in bigger volumes and at faster rates than any other country in the world has ever attempted. Since it takes so long to develop significant new energy supplies, there is almost no way to smooth out the timing of China's energy needs. It makes far more sense to develop as much as can be done as fast as possible, regardless of whether this creates a temporary glut from time to time.

As this process begins, it is highly important that the rest of the world appreciate how critical it is to China's long-term economic improvement that it has access to an adequate amount of energy supplies. Too often history has shown that it benefits no one to have a rapidly expanding economic force suddenly become insecure about energy resources. Pulitzer prize winner, Dan Yergin, pointed out in *The Prize* that ever since petroleum needs became synonymous with economic and political power, most wars have centered around securing more reliable energy supplies.

China must achieve numerous and difficult tasks almost simultaneously to satisfy its energy demands. First, it needs to embrace every single way to improve its energy efficiency. Second, China needs to acquire the technical means to reduce the environmental impact of its coal consumption. Third, it must expand domestic exploration and development of its indigenous hydrocarbon reserves. Fourth, it must compete aggressively in the international market to acquire "foreign" reserves and production.

Increasing China's energy efficiency is the single easiest and least costly way of tackling its vast energy needs. Every percentage of energy saved by better efficiency reduces China's incremental energy by 175,000 barrels per day of oil equivalent. Many of China's massive state-owned enterprises are undoubtedly very energy inefficient, similar to the giant industrial complexes in Russia.

While there must be ample scope to improve the energy efficiency throughout much of China's industrial energy usage, there are also practical limits to this solution. For instance, the fastest growing parts of China's economy, which account for most of China's incremental energy needs, are the newer private sector companies and China's emerging consumer class. Both of

these new energy users cannot be very energy efficient since they use so little energy to date. So, energy efficiency is probably only a “band-aid” or short-term easement to China’s longer-term energy needs. This cannot become a meaningful solution for China’s insatiable energy needs because the per capita energy use is so low throughout China today.

China will also need all the external help it can garner to maximize the daily production of its domestic oil and gas supply. Thus, whether or not China has actually tried to “high grade” its exploration acreage by keeping its most promising tracts for itself, either the practice or merely the doubts and suspicion held by many international exploration companies about this practice need to be dispelled. The Western E&P licensees in China need to consider the lack of evidence that such a practice has been a conscious Chinese trait. Witness the success of CNOOC on offshore blocks abandoned by Western partners. China needs all the international help it can get to bring on domestically produced oil and gas.

Finally, CNPC and CNOOC should be encouraged to increase their already aggressive moves to become key players in the international oil and gas scene. The aggressive investment stance of CNPC in the summer of 1997 should merely be a hallmark of its long-term behavior. No Western oil company or government should become alarmed by this. It differs in no way from the Seven Sisters actions from 1930 on. CNPC’s motivation, though, is not simply more profit. It is simply trying to do everything possible to insure a safe and reliable energy supply so the country’s dreams of modernization can continue.

Embedded in China’s energy future is a host of serious geopolitical issues. These start with China’s almost paranoiac obsession of its ownership claims to the hydrocarbons throughout the South China Sea. According to many Chinese historians, the country gained proper title to any valuable assets exploited from the South China Sea from a treaty negotiated in the 15th Century (according to one version or as far back as 2 B.C. in another). These rights stretch to the borders of Indonesia, the Philippines and Vietnam. Unfortunately, all of China’s neighbors feel differently about this issue, as evidenced in several 1997 border disputes.

A common ground solution to these arguments is to encourage China to explore in all areas with a clear right to use any added hydrocarbon supply, much like the North Sea countries encourage foreign E&P companies to help exploit North Sea reserves. If the leaders of China

understand that only the net profit of acreage whose title is in dispute, they are likely to behave in an entirely different fashion.

It is also clear to me that the future of China's economy has an enormously important link to the long-term development of both Siberia and Central Asia. Both regions have extensive energy resources but both are remarkably poor. They have few options to get their most logical source of wealth, their vast supply of hydrocarbons, to places where it is in demand.

China could easily be the salvation and could create a true "win-win" situation for both China and these two areas. Russia is clearly demonstrating signs of concern or insecurity that Central Asia's oil and gas will ultimately crowd out Russian oil exports. The various maneuvers to make sure all key Central Asian pipelines end up at Russian ports demonstrates how strongly the Russians feel about this issue. This concern is understandable since Russia's oil exports to the West are still the most critical component for Russia to achieve an economic recovery. By reversing the flow of Central Asian oil and gas supplies from the West to the East, Russia could be less paranoid about the Central Asian threat.

China and Siberia have always had historical ties. Trading between the two regions has been underway for thousands of years although it has only recently become apparent that Siberia's economic outlook could remain bleak for a long time while China's outlook is so positive. China's biggest problem is too large a population. One of Siberia's key problems is having too few capable hands. Siberia's birth rate is close to the lowest in the world. One country has an ample foreign exchange surplus, while the other has to continually retabulate its most recent deficit.

Because the problems of one region relate so closely to the others problems, there must be grounds for cooperation and possibly avenues for profit growth far in excess of what is now being projected.

Looking at these issues in a positive light, there are tremendous benefits for the East Asian and Central Asian regions of the world if China can solve its future energy needs by tapping into both Siberia and Central Asia for more oil and gas. This allows China's economy to grow as fast as it wants to and it also pumps funds into Siberia and Central Asia which will help both these impoverished areas expand.

In one way or another, China simply needs to economically “annex” Siberia from Russia. Only time will tell whether this is a mere economic transfer or something far more important to Russian and Chinese future relations.

The South China Sea holds much larger hydrocarbon resources than is currently being exploited. China’s leaders feel their territory extends far beyond current borders. Resolving these border issues should be a high priority item on their political agenda. Otherwise, continuous disputes similar to the skirmishes that took place between the Vietnamese and the Chinese this spring or, more recently the skirmishes between the Philippines and the Chinese over the Spratly Islands a month or two later could erupt into far more serious arguments or even war. This is a serious issue that the rest of the world should not ignore.

The West has an important role to play as this development occurs. The technology needed to satisfy China’s insatiable oil and gas demand currently resides almost entirely in the hands of U.S. and European oil and gas companies and particularly the oil service companies and manufacturers of petroleum equipment. To tap into this opportunity, the U.S. needs friendly trading relations with China. We have to resist using trade sanctions every time a political dispute arises in any of these countries.

If the oil service industry is allowed to fully participate in maximizing the fullest potential of China’s oil and gas reserves, the growth created from this expansion could make the North Sea’s need for oil services over the past 20 years look modest. The revenues themselves will be enormous from equipping the pipelines needed to delivering oil and gas to China.

China has a strong indigenous oil service infrastructure that has been remarkably efficient at keeping the mature fields producing most of its oil. However, this oil service network and the various petroleum equipment manufacturing units in China could benefit from stronger ties with the Western oil service industry, particularly as the “technology revolution”, which is impacting almost every phase of drilling and completing wells, plays out.

There is an enormous benefit if the rest of the world joins forces with China to help it secure a safe, dependable, affordable and environmentally friendly energy supply. Conversely, there are enormous potential problems if China’s energy demand cannot be satisfied.

China's Herculean task of trying to solve its serious environmental problems, let alone weaning itself from coal, needs the understanding, patience and assistance of the rest of the industrialized world. Lecturing China to take its pollution problems seriously is pointless and there is ample evidence that the Chinese leadership is not only acutely aware of this pollution problem, but is taking many actions to combat it.

Threatening China's trade status or invoking other sanctions to force some unattainable ceiling to its emissions is counter productive, not to mention remarkably hypocritical since the per capita pollution from China today is still minuscule compared to the U.S.

The world's environmental leadership needs to appreciate the fact that increased use of hydrocarbons in China, which include both environmentally friendly natural gas and oil, are China's only realistic hope of reducing the pollution from coal consumption. Unfortunately, both create carbon and CO₂ emissions but both emit less than coal. China's oil usage, according to the Lawrence Berkely National Laboratory, University of California, generates approximately 20 percent less carbon and CO₂ emissions than coal as seen in the most current sampling in 1993, long before the recently banned use of leaded gasoline. Natural gas emission from China's coal creates only 60 percent Carbon emissions and 49 percent CO₂ emissions as China's use of coal. (Table 12).

Table 12
China's Fuel Source Relative Emission Rates

	Coal	Oil	Natural Gas
Carbon Emissions	100%	82%	61%
CO ₂ Emissions	100	82	49

Source: Lawrence Berkley National Laboratory, University of California.

Building An Energy Bridge

A variety of excellent speakers contributed to making the Harvard Business School Alumni Association's conference on Greater China so successful. So many of the conference's knowledgeable speakers spoke optimistically and seemed to eagerly await the reuniting of Hong Kong with the rest of China. Not surprisingly, the most optimistic participants tended to be Overseas Chinese. A few skeptical attendees wondered whether this enthusiasm was merely a facade or a sense that it would be politically incorrect to not give the "party line" as the day of reunification was so near at hand.

To me, the enthusiasm seemed genuine and similar to what I would suspect to hear from panelists in the United States if we were about to get New York City back after 150 years had a country like Colombia taken it away from the U.S. in a drug war. Think of the pride that would spread throughout the U.S. at finally seeing New York City return to its motherland or imagine the excitement of finally integrating the economic might of New York City into other parts of our country.

But, of all the excellent speakers at this Harvard Business School conference, the most impressive was George Y. B. Yeo, a 1985 Harvard Business School graduate (and Baker Scholar) from Singapore who returned to Singapore after completing his degree and becoming a Brigadier General in Singapore's Air Force before entering politics. He is now Singapore's Minister of Arts and Information and Singapore's second Minister of Industry.

Mr. Yeo first spoke about the pride that Overseas Chinese have at the economic reforms and advances taking place in China today. He put this pride into perspective by reminding the audience that most Overseas Chinese have been pariahs in the countries where they reside, but still managed to become dominate forces in the economies of most of these same countries. Despite being shut out of the political hierarchy, they achieved this economic prominence through hard work, strong ethics, a sense of family and a deep patriotism towards other Chinese.

“To then contemplate all of China achieving this same prosperity unleashes a deep sense of pride and excitement to most Overseas Chinese and an urge to cooperate in this transformation of China,” said Yeo. *“When you add up all the potential these reforms and advances have for China, it is hard to imagine that the country will not someday regain its position as one of the two greatest economic powers on earth.”* He then observed that over the course of history, every time such a major power change occurred, it was also accompanied by war.

Yeo concluded his talk by saying, *“China’s reawakening could be the first time in history where such a significant power shift occurred without war also occurring. But to make this happen, bridges need to be built. The bridges need to link China’s progress to benefits for the rest of the world, too. Fortunately, many bridges need to be built and all are wanted by the Chinese.”*

“But,” warned Mr. Yeo, *“if the various other countries decide not to build these bridges, for one reason or another, then we all might as well go home and get into our uniforms.”*

He must be correct. A country as important and big as China cannot be isolated. All forms of economic and cultural bridges need to be created between China and its neighbors and trading partners, but perhaps the biggest bridge of all is the energy bridge that China needs so it can obtain secure and reliable sources of hydrocarbons from its own resource base and various other parts of the world.

These energy bridges must be built because continuing growth in China’s economy is almost inevitable. Its resources are too vast and the desires and skills of its people are too great for this not to occur.

China will hopefully prove to be serious in its commitment to decrease its dependence from coal as well. But, this task alone will need assistance from countries throughout the world to provide technical equipment to reduce coal emissions because China’s coal use will certainly continue to grow, even if its total percent of China’s fuel mix begins to fall. Such help in just one more critically important energy bridge.

Pipelines from Central Asia and Siberia are more vital bridges that can play a major role in securing more oil and gas in plentiful supplies if the money needed to build these expensive hydrocarbon highways can be financed. Sources of new oil and gas supplies from the East and

South China Seas and from places as diverse as Indonesia, the Middle East, Venezuela and even Alaska are other forms of energy bridges.

Building these bridges with China will benefit both the Chinese as well as the rest of the world. It is hard to imagine a region of the world that does not have a stake in ensuring these bridges are built. We simply cannot ignore these needs. Otherwise, George Yeo's advice to go home and put on our uniforms may sadly prove correct. Energy is the underpinning of China's drive to prosperity. Without more energy, all the advances that China is making will grind to a halt. The benefits to the entire world by having China develop into a prosperous modern country are too important to let this effort fail. China's energy needs can be met, but many energy bridges must be built.

A lot of serious money can be made for millions of companies throughout the world if China succeeds. But to succeed, China must solve its energy needs. Ironically, the biggest winner in making this happen is the worldwide oil service industry. As goes China, so goes the oil service industry because China's success is remarkably entwined in the drilling and equipping of more wells than have ever been tackled before!

Appendix

Matthew Simmons began studying the dynamics of the oil and gas industry as a Research Assistant and then Research Associate of Harvard Business School 30 years ago. In 1974, he founded Simmons & Company International in Houston, Texas, as the first investment banking firm to exclusively concentrate its expertise in advising oil service companies and petroleum equipment manufacturers.

From the firm's modest beginning in 1974, it has grown to be the leading investment banking firm to the worldwide oil service industry, having assisted its client base in over \$20 billion of investment banking transactions.

Mr. Simmons' writings and analyses of the worldwide oil and gas industry are frequently published in the industry's leading trade journals along with the most respected financial media including the *Wall Street Journal*, *Barrons*, *The Economist*, *The New York Times*, *Fortune* and *Business Week*.

Mr. Simmons is the past chairman of National Ocean Industries Association and the past president of the Harvard Business School Alumni Association. He is a member of the National Petroleum Council and the Interstate Oil & Gas Compact Commission.