

Forecasting Chinese Energy Demand: Is the World in Denial?

By Malcolm Shealy and James Dorian*

Introduction and Background

Only a few years ago Chinese government leaders were optimistic that their country could quadruple its GDP between 2000 and 2020 while only doubling energy use. For any other developing country this would be considered an unrealistic goal, as energy consumption during development tends to grow as fast or even faster than GDP. Yet, China had quadrupled GDP while only doubling energy use from 1980 through 2000, so government officials reasoned they could do it again.

However, China is already off track in meeting its 2000-2020 energy consumption goals, and the country is now at a point where it will be nearly impossible to prevent energy use from more than doubling. As shown in Figure 1 energy use has grown faster on average than GDP since 2000. Notwithstanding, China's government, as well as major energy statistics agencies including the International Energy Agency (IEA) and United States Department of Energy (DOE), have been so captivated by the original, optimistic story-line that even their latest forecasts have not caught up to the reality of what is happening in China.

In this article we first examine the period from 1980 through 2000, and explain why it was unusual for the Chinese energy industry. Second, we look at the changes in China since 2000, including the critical electric power generating sector. Using a simple thought experiment, we then illustrate that even with very conservative assumptions about Chinese GDP growth and income elasticity of electric demand out to 2025, the country will experience much higher coal demand and emit much greater volumes of carbon emissions than forecast by IEA, DOE, as well as other forecasters. This leads to some final thoughts on the implications of future Chinese energy demand on global energy markets.

Why the 1980-2000 Period in China Was Unusual

During the 20 year period from 1980 through 2000, China quadrupled GDP while only doubling energy use. This is quite unusual. Developing country energy use typically grows faster than GDP as heavy industry develops and as consumers transition from non-market fuels such as firewood to market-based fuels such as kerosene and electricity.

Even more unusual for China was the weak growth in electric demand. Electricity is the most versatile, high-quality source of energy. In developing countries electricity consumption is expected to grow faster than GDP, which implies an income elasticity of over 1.0. Yet, from 1980 through 2000 in China, electricity consumption grew only about 80 percent as fast as GDP, yielding an income elasticity of around 0.8. In addition, reported growth in coal consumption slowed significantly in China during the late 1990s, fueling optimism that China was somehow different—that its economy could grow faster than energy use on a continuing basis and even transition away from coal.

Various explanations have been offered for why Chinese energy demand grew so much slower than for other developing countries. One prominent explanation is that the Chinese were transitioning from inefficient state enterprises to more modern and efficient means of production. The consequent efficiency improvements meant that the economy could grow faster than energy use. Another explanation is that faulty Chinese GDP or energy statistics led to skewed income elasticities. Regardless of the actual reasons, the picture has recently changed.

Relationship Between Energy and Economic Growth Changed Abruptly After 2000

The Chinese economy is vastly different today than it was two decades ago. Energy linkages throughout the economy are greater than before, more costly and complex, more reliant on long-distance transport within China, and more dependent on foreign supply chains of oil, gas, and increasingly, coal. Since the 1980s, hundreds of thousands of kilometers of new pipelines, railroads, and highways have been built, which are necessary to move increasingly larger volumes of oil, gas, and coal throughout the country. Oil use for vehicle transportation in China has grown several-fold since the 1980s. Energy prices have been decontrolled and allowed to rise to near market or market levels.

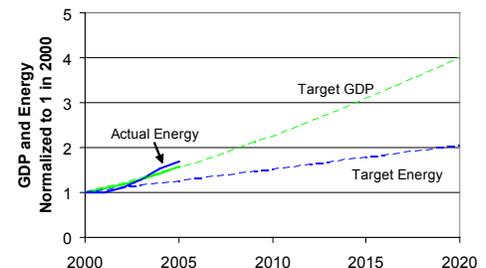


Figure 1
Actual Energy Use in China is Well Above Target Since 2000.

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Beginning in 2000, the observed relationship between energy and GDP began to change. First, the growth rate in electricity consumption rose above the growth rate in GDP for the first time in years, and continued to grow faster than GDP, yielding an income elasticity averaging 1.3 over the period 2000-2006. This sudden change in the nature of electricity demand occurred for two primary reasons: (1) the inefficient state enterprises have now become relatively more efficient and, as such, achieving additional energy savings from industry today is more challenging and costly; and (2) the Chinese economy has grown enormously, resulting in a smaller share of the pie for state enterprises. Today, Chinese electricity demand is behaving like that of a normal developing country and shows no sign of reverting to the earlier pattern. Indeed, Chinese goals for rapid urbanization of upwards of 400 million people by 2030 will likely push electricity demand up even faster.

A second major change is the rapid increase in coal use starting in 2002. Part of this increase represents catching-up after the underreporting of the late 1990s when the Chinese government had attempted to shut down thousands of small inefficient coal mines in order to meet World Trade Organization ascension requirements. Another reason is that coal use is increasingly driven by electric demand. For example, in 1990, about 25 percent of coal production went to electric utilities; by 2005, that figure had grown to 55 percent. Clearly, robust growth in electricity consumption since 2000 has contributed to robust growth in coal demand—as almost 80 percent of Chinese power generation is coal-fired. The increase in coal use, along with a substantial increase in oil demand, has caused Chinese energy demand to rise at a rate of about 11.2 percent per year from 2000-2005, while GDP growth has averaged 9.6 percent per year.

What Does China's Energy Future Look Like Through 2025?

We next examine what the future may hold for China's energy consumption using a simple thought experiment, then compare the results to the most recent IEA and DOE forecasts. Given that seven years have passed since 2000, we have chosen to forecast over the 20-year time period from 2005 through 2025. Complete historical data is available through 2005, while some data is available through 2006. Since electricity increasingly drives Chinese energy demand, we begin with a discussion of electricity.

Electricity

To be conservative, we assume that Chinese electricity consumption grows only 1.1 times as fast as GDP through 2025, down from its current ratio of 1.3. Figure 2 shows how Chinese electric demand would grow for two different average GDP growth rates—6.5 percent and 7.2 percent. The 6.5 percent GDP growth rate is close to the IEA and DOE GDP growth assumptions. The 7.2 percent growth rate was chosen because it gives a quadrupling of GDP over 20 years, so corresponds to the targeted Chinese growth rate. Figure 2 also shows recent IEA and DOE forecasts of Chinese electric demand.

Why are the IEA and DOE forecasts significantly lower than the lowest-growth thought experiment? IEA and DOE assume low GDP growth rates, but also assume income elasticities that are much lower than those we have witnessed recently in China. For example, the IEA November 2007 reference case forecasts that from 2005 through 2030 electricity consumption will grow significantly slower than GDP—4.9 percent average annual growth in electricity versus 6.0 percent growth in GDP—which implies an income elasticity of only 0.82. The Chinese forecasts also imply an unreasonably low income elasticity of electric demand.

As the IEA and DOE forecasters have been confronted by rapidly rising near-term electric consumption in recent years, they have repeatedly shifted their forecasts upward (see Figure 3). These forecasting problems will continue until IEA and DOE update the relationship between growth in electricity consumption and growth in GDP.

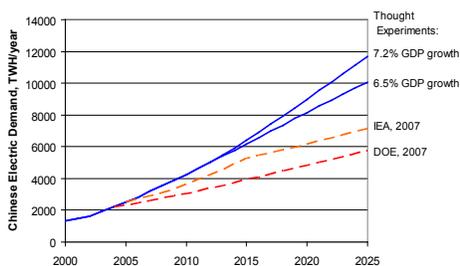


Figure 2
The Thought Experiments Yield Much Higher Forecasts of Chinese Electric Demand in 2025 than IEA or DOE.

Coal

Electricity demand increasingly drives coal demand in China. The Chinese electric sector accounted for 55 percent of Chinese coal demand in 2005, and the share has been steadily rising. As IEA, DOE, and the Chinese government underforecast Chinese electric demand, they subsequently underestimate Chinese

coal demand.

Figure 4 continues our thought experiment by demonstrating how Chinese coal consumption would grow for three different average GDP growth rates to 2025—6.5 percent, 7.2 percent and 10 percent per annum. This computation is conservative in three important respects. First, it assumes more rapid growth in non-coal electric generation than posited by either IEA or DOE (e.g., a tripling of hydro generation by 2025 and a 10-fold increase in nuclear generation). Second, it assumes that the efficiency of converting coal to electricity is higher than the IEA historical data implies, and that the efficiency is rising over time. Third, it assumes that non-electric coal consumption (e.g. for iron and steel) grows only

one-fifth as fast as GDP—meaning that a 10 percent growth in GDP causes only a 2 percent growth in non-electric coal consumption.

Despite conservative assumptions, with a 7.2 percent GDP growth rate in China to 2025, the country would use over 6 billion tons of coal in 2025, almost three times the current amount of coal produced and used. Cumulatively this amounts to 86 billion tons of coal from 2005 through 2025, out of a roughly 115 billion ton reserve base—implying much reduced domestic coal availability by the end of the period. The main culprit for the rapid rise in coal demand is the rapid growth in electricity consumption. To our knowledge, there are no forecasts today suggesting a tripling of coal use in China within two decades, or what the ramifications of such growth could mean to the world's efforts to combat global warming.

Such rapid growth in coal use through 2025 would present major challenges to the Chinese economy, environment, and transportation system, and it would raise some doubt as to whether China could even meet a 7.2 percent average annual growth rate to 2025. Indeed, China's railroad cars and tracks are already over-burdened, and a competition for limited rail car use has developed among coal, iron ore, steel, grains, and many other commodities, including oil (see Figure 5). The increase in coal transport by rail is outpacing rail track expansion in China, displacing other freight, and accelerating a shift to less efficient transport by road. Looking ahead, it is difficult to envision how another 4 billion tons of coal per year could be produced, transported and used in China, even with plans for dramatic railroad expansion now called for in China's 11th Five-year Plan. Since China has become a net coal importer this year, increasing volumes of coal would have to be imported to meet a tripling of use—and it is very questionable where such potentially huge volumes of coal would come from.

Oil

Oil consumption in China has risen only about 70 percent as fast as GDP, yielding an income elasticity of 0.7. However, that picture may change soon. First, the Chinese are purchasing vehicles at a very rapid rate, and the notion from a few years back that the Chinese are somehow different and will be content to ride bicycles has been disproved (see Figure 6). Second, bottlenecks in rail can divert goods to long-haul trucking, which uses far more oil per ton-mile. Finally, the Chinese industrial base is a major consumer of petrochemicals and is growing rapidly.

Carbon Emissions

Coal supplies about 70 percent of Chinese energy needs, and this percentage is likely to remain high for decades, as coal is less expensive than many of the alternative fuels available to China. Coal, therefore, will remain the dominant contributor to Chinese carbon emissions looking ahead. Figure 7 shows the impact of growing coal consumption in China on carbon emissions, as well as growing oil and natural gas use. Once again, our thought experiments yield much higher numbers than either the IEA or DOE reference cases, even with conservative assumptions. Importantly, the Chinese could possibly double U.S. carbon emissions by 2025—China overtook the US in 2006 according to Dutch scientists. Such expected growth in carbon emissions in China implies that worldwide efforts toward reducing global warming and greenhouse gas emissions will likely be overwhelmed by China if the country's current path of energy and economic development continues.

Only Way Out: Slower Economic Growth

Various alternatives have been proposed for reducing Chinese dependence on fossil fuels and slowing the growth of coal use and Chinese carbon emissions. Such alternatives have included boosting nuclear and wind power, increasing use of biofuels, rapidly developing a natural gas and LNG domestic industry, and increasing energy efficiency in power generation and end uses through price and policy reform. Each option has limitations and challenges. However, to keep with a conservative scenario, our thought experiment assumes relatively rapid penetration of all of these alternatives—often more rapid than assumed by IEA and DOE. Nonetheless, even under optimistic assumptions regarding alternative energy forms in China, the share of electricity generated by coal through 2025 increases in the 7.2 percent GDP growth case, and remains about the same in the 6.5 percent GDP growth case. The reason is that the income elasticity

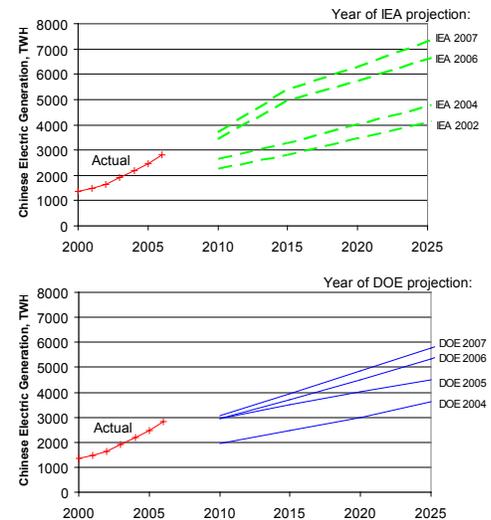


Figure 3
Like Most Chinese Electricity Demand Forecasts, IEA and DOE are Consistently Revised Upwards

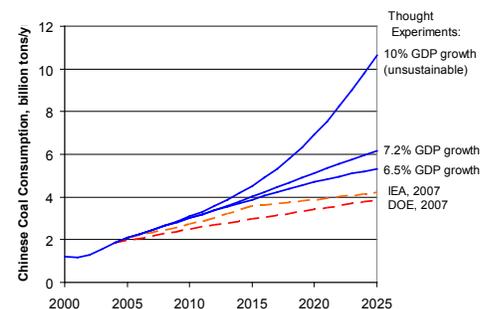


Figure 4
The Thought Experiments Yield Much Higher Forecasts of Chinese Coal Demand in 2025 than IEA or DOE.



Figure 5
China's Coal Deposits and Major Rail Infrastructure.



Figure 6
Chinese Bicycle Congestion has Given Way to Auto Congestion.

believe the world has not yet come to grips with the possibility of coal use in China increasing three-fold over today's levels. As such, we believe further studies are warranted to address this issue and answer fundamental questions suggested by our analysis, including: (1) will infrastructure bottlenecks in the all-important Chinese coal sector lead to a slowdown in economic growth sometime next decade; and (2) if energy forecasters consistently underestimate long-term Chinese energy demand, how accurate are their forecasts of global energy consumption. The risk of denial is that China and the world fail to recognize the magnitude of the task ahead in meeting energy needs, and thus fail to act soon enough to prevent significant disruptions.

of 1.1 drives electricity consumption upward at a rapid rate, one that cannot be matched by hydro, nuclear, and renewables as a group.

China has ample opportunity to increase the energy efficiency of its economy. But without dramatic and even unprecedented price and policy reform there will likely be limitations on how much efficiency gains can slow growth in overall energy consumption. China's reliance on coal power plants, for example, will remain the norm without a dismantling of the huge power monopoly—which is improbable. While efficiency gains are possible throughout Chinese industry, including within the cement, iron ore and steel, and chemical sectors, gains to date have not managed to reverse rising energy demand. More importantly, China's continuing drive to achieve robust economic growth and maintain jobs—particularly at the local and provincial levels—will keep the primary focus of industry on output and not on reduction in energy use.

With alternative fuels and energy efficiency gains likely offering only marginal help in reducing Chinese coal reliance to 2025, slower economic growth is probably the only viable solution to the current skyrocketing growth in Chinese energy demand. If the Chinese government does not reign in economic growth in a controlled manner, then various bottlenecks in the energy supply system or environmental

problems will probably force them to slow their growth in a less-controlled manner.

Conclusions and Implications

As shown by our thought experiment, the IEA and DOE reference case scenarios do not represent a continuation of current trends, but instead assume an unexplained, radical reduction in Chinese energy intensity. This is evidenced by their repeated upward revisions of projections for electricity, coal, and energy in general, as well as by an unreasonably low income elasticity of electricity consumption. The actual trajectory for Chinese energy consumption is proving to be much higher than their forecasts, and this trend will continue until IEA and DOE come to grips with the high income elasticity of electric demand.

Our trajectory for Chinese coal consumption to 2025 has stark implications both for sustained Chinese economic growth as well as for the world's environment. The authors

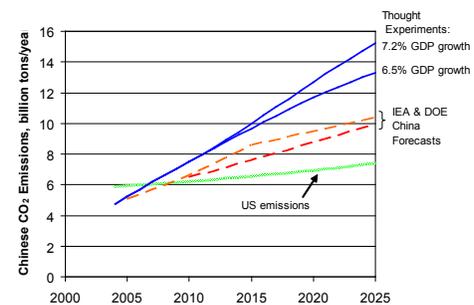


Figure 7
IEA and DOE Forecasts Significantly Understate the Potential Growth in Chinese Carbon Emissions.