

THE RISE OF CHINA ***AND ITS ENERGY IMPLICATIONS***



China's Oil Sector: Trends and Uncertainties

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CHINA'S OIL SECTOR: TRENDS AND UNCERTAINTIES

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PREPARED BY THE ENERGY FORUM OF THE
JAMES A. BAKER III INSTITUTE FOR PUBLIC POLICY
AS PART OF THE STUDY
THE RISE OF CHINA AND ITS ENERGY IMPLICATIONS

DECEMBER 2, 2011

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ACKNOWLEDGMENTS

The Energy Forum of the James A. Baker III Institute for Public Policy would like to thank The Institute of Energy Economics, Japan, and the sponsors of the Baker Institute Energy Forum for their generous support of this program. The Energy Forum further acknowledges contributions by study researchers and writers.

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The Rise of China and Its Energy Implications is a major research initiative to investigate the implications of China's oil and natural gas policies and domestic energy market development on global energy markets. This study focuses on the influence of China's energy development on U.S. and Japanese energy security and global geopolitics. Utilizing geopolitical and economic modeling and scenario analysis, the study analyzes various possible outcomes for China's domestic energy production and its future import levels. The study considers how trends in China's energy use will influence U.S.-China relations and the level of involvement of the U.S. oil industry in China's domestic energy sector.

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**ABOUT THE INSTITUTE OF
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The Institute of Energy Economics, Japan (IEEJ), was established in June 1966 and specializes in research activities in the area of energy from the viewpoint of Japan's national economy in a bid to contribute to sound development of Japanese energy supply and consumption industries and to the improvement of domestic welfare by objectively analyzing energy problems and providing basic data, information and the reports necessary for policy formulation. With the diversification of social needs during the three and a half decades of its operation, IEEJ has expanded its scope of research activities to include such topics as environmental problems and international cooperation closely related to energy. The Energy Data and Modeling Center (EDMC), which merged with the IEEJ in July 1999, was established in October 1984 as an IEEJ-affiliated organization to carry out such tasks as the development of energy data bases, the building of various energy models, and the econometric analyses of energy.

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I. Introduction¹

Even a cursory glance across the vast array of forecasts, outlooks, and annual reviews that fill the news at the start of every new year reveals how much China looms large in the energy world. While the Western world remained mired in recession, China boomed and this single country market is increasingly seen not only as the leader of Asia-Pacific energy trends, but the future global epicenter for energy demand.

In early 2011, the China Petroleum and Chemical Industry Federation projected crude oil consumption would rise 6% in 2011, a dizzying pace of growth in a global economy only now recovering from the crash of 2008. Yet the group predicted that natural gas consumption would rise this year by 15%.²

Already Asia Pacific's largest refiner and oil consumer and the world's largest coal user, China seems poised to shape not only regional oil, gas, and coal sectors, but also energy worldwide. And since Beijing increasingly draws on imported oil, gas, and now coal, according to the government's National Energy Administration (NEA), this market will top 2010's coal imports of 146 million metric tons per annum (MM MTA)³—Beijing's long run of sustained economic growth has not only made it the arbiter of regional energy patterns, but a major shaper of energy trends worldwide. China will ramp up conventional fuel imports and production to continue to power economic growth, despite trumpeted efforts to develop clean, renewable, and alternative energy.

The basic energy statistics reported remain astonishing. The NEA predicted for 2011:

Accelerated development of 14 separate coal mining centers will provide sufficient supply to keep up with national demand. Coal accounted in 2010 for a higher percentage of base energy supply in this market than any other major economy, making up 70% of the country's base energy use and 80% of power generation fuel.

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This coal, in large part, will underpin forecast power demand growth of “only” 9% in 2011, with power demand reaching a total of 4.5 trillion kilowatt-hours (KwH) after a 2010 rise of 14.6%.

Apparent oil demand would rise 12.3% to 449 MM MTA, or 8.98 million barrels per day (b/d). Crude imports would continue to grow despite 2010's unusually large gain of 6.9%. In 2010, the NEA said crude imports rose 12.5% to 239.3 MM MTA, or nearly 4.79 million b/d, and domestic oil output increased to 203 MM MTA, or 4.06 million b/d.

Even greater gains were seen in gas. The NEA forecast a 20.4% jump in demand to 130 billion cubic meters (BN CM), or 12.57 billion cubic feet per day (BN CFD), outpacing a 16% rise in domestic gas production that will reach nearly 110 BN CM (10.64 BN CFD)—a gap of over 1.93 BN CFD. To help fill that gap between expected gas use and anticipated gas output, piped gas volumes from Central Asia will have to rise substantially above the 4.4 billion cubic meters, or 425 million cubic feet per day (MM CFD), recorded in 2010 and LNG purchases will have to be boosted sharply from 2010 import levels of nearly 13 BN CM (967 MM CFD). China National Petroleum Corp. (CNPC) is expected to quadruple piped gas imports by end-2011 to reach 17.7 BN CM (1.714 BN CFD). The government predicted gas would make up 8% of national primary energy use by 2015, nearly double 2009's level.

The impressive numbers continue for non-hydrocarbon energy. Beijing has 20 gigawatts (Gw) of hydroelectric capacity under construction—nearly one-tenth of its already-operating 210 Gw. Already the world's largest producer of wind power at 41.8 Gw capacity, the government plans to add a further 14 Gw, while connecting much of current isolated power generation to the national power grid. Solar power capacity continues to grow at an astonishing pace, with 300 megawatts (Mw) planned for completion in 2011 after 400 Mw were completed last year, raising total capacity to 700 Mw. Conventional non-hydrocarbons have not been neglected either, as China has 28 nuclear reactors under construction totaling 30.97 Gw, despite misgivings after Japan's tsunami disaster.⁴

How can we interpret the numbers and what do they augur for the future? This paper will focus on China's current and future place in the regional and global energy sector and argues that much

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of the outside world's view of Chinese energy is distorted by fundamental misconceptions that reflect the view of traditional Chinese oil and gas use.

Statistics

Statistics—or rather the lack of timely, accurate, public, comprehensive, coherent statistics—are the bane of the China energy analyst. Unlike almost all major oil markets around the globe, China lacks official demand and sales statistics on a national, provincial, municipal, or sectoral level; the government releases no official crude, oil products, or gas stock figures. Basic oil and gas statistics such as import/export trade, refinery output, and crude and gas production by field are given, at best, on a monthly basis—nothing like the weekly summary provided to oil markets in the United States by the American Petroleum Institute.

Most analysts agree that customs data, consisting of major oil products and crude, has been consistently the most accurate statistics offered by the Chinese government over the past decade, but even there problems exist. Bunker sales—considered in some countries exports and in others domestic demand—have never been included in import/export data, and APEC estimated that in 2010 fuel oil sales for ships' fuel approached 200,000 b/d.

The complete absence of national demand and stock data on a timely basis has been noted. Analysts fall back on the annual China Statistical Handbook to check their calculations, and this is released 18 months after the year covered. Yet for statistics available and issued regularly, we see refinery production and company sales as the areas most in need of reform. While the two biggest downstream state firms—China National Petroleum Corp. and China Petroleum and Chemical Corp. (Sinopec)—do release such data, they unwittingly have distorted perceptions for product supply. As of January 2011, APEC surveyed 13.4 million b/d in Chinese base capacity. Yet the third largest national refiner, China National Offshore Oil Corp. (CNOOC), does not release any refinery production data, despite operating 1.1 million b/d, nor do China's small, independent refiners, which operated roughly 1.7 million b/d in distillation, with about three-quarters of that focused in the northeast province of Shandong. No official data on refinery output ever has been released on a regular basis from either of these two groups and of course mini- and micro-refineries, often operating semi-legally, have their output unrecorded.

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A further difficulty with Chinese statistics has been the failure of the government and companies to adopt fully international energy data norms, despite pledges to the International Energy Agency (IEA) and other multilateral organizations to standardize energy statistics to international industry practice. A good example is the term “petrochemical feedstock,” used in government statistics as well as CNPC/Petrochina and Sinopec data. Some analysts take this to mean “naphtha,” specifically paraffinic naphtha used to produce olefins (mainly plastics). Yet while paraffinic naphtha made up most feedstock use over the past decade, petrochemical feedstock includes feedstock used both for olefins and aromatic petrochemicals and also has been comprised of gas oil, direct use condensate, limited LPG, and experimentally, ethane.

Refining terminology is a minefield for the unwary. Hydrofining is often used for cracking (mild or severe), while sometimes it is meant as hydrotreating, or even hydrodesulfurization. Vacuum distillation unit (VDU) capacity has never been stated for most Chinese refineries, and this is an important indicator of how easily a refinery's distillation tower can process heavy crudes. No professional association lists official design capacity for refinery units, nor does the government track such basic data.

But the problems in statistics are not solely of poor quality or fragmentary data, but also spring from the misperceptions and misconceptions of many Western analysts often unfamiliar with the Chinese market in any practical way. With limited commercial experience, they make fundamental misjudgments. When they read that China is moving to European Union (EU) product specifications (known as Eurospecs), for example, they assume that future Chinese product quality will fully comply with EU standards. China, though, has never followed Eurospec quality standards point-by-point. Further, many analysts fall into the mental trap of many energy economists assuming that because Western oil and gas markets evolved in a certain fashion, Beijing is compelled to follow that development path in lockstep fashion. This has been shown to be completely false in the past, and we believe China's differences from the West will continue to be demonstrated in the future.

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When the reader reviews numbers in an analysis of Chinese oil or gas, the guiding rule is caveat emptor—let the buyer beware. What is presented as “demand” is often apparent demand; what is said to be “gas production” is often only wellhead output, not usable gas.

Stimulus

One of the more interesting events that unfolded over the recent recession was the reaction of governments worldwide to attempt to revive flagging demand in face of the fear that swept markets after the collapse of Lehman Brothers in October 2008.

China, like most major economies, moved to quickly implement a stimulus program to jump-start demand and stem market panic. Beijing implemented its first stimulus package of \$568 billion in November 2008. It quickly followed up with a second stimulus round, focusing on refinery and petrochemical investment, that totaled more than \$800 billion and was implemented in February 2009, and concluded with a final \$440 billion, concentrating on renewable energy, by September 2009.

The vast bulk of this funding went to completing refinery and petrochemical capacity that was already approved by the central government and often had construction under way. Completion of a number of oil and gas pipelines was similarly given top priority in stimulus funding. Almost all direct funding was targeted at jump-starting stalled capital projects in the domestic market. Funding for state companies buying upstream assets abroad never faltered despite the end-2008 downturn, but was accounted separately from, though parallel to, stimulus funding. Of the roughly \$2 trillion offered in stimulus funding, we estimate that about 60% was earmarked for refining, petrochemicals, and pipelines; of that, \$800-\$900 billion was used in refining, petrochemicals, and pipelines, while the remaining \$300-\$400 billion went to renewable energy, mainly wind and solar power.

In contrast to many Organisation for Economic Co-operation and Development (OECD) economies, Beijing's stimulus efforts had a clear and near-immediate impact in spurring domestic economic growth. Oil demand began to revive by early 2009. Why, then, the great difference? The answer is simple: China is in transition from a planned command economy to a

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free market. It has a far higher share of state investment, and a far lower proportion of private consumption, than the typical OECD economy.

A simple macroeconomic comparison between the economies of China and the United States answers why the two were impacted differently by the Great Recession. Consumer demand (i.e., private consumption) in China at its peak was 25% in 2008, compared to roughly 70% in the United States. Fixed asset formation in China was roughly 70%, with two-thirds of that coming from government investment, compared to roughly 22% in the United States. Exports accounted for about 5% of the Chinese economy and less than 3% of the U.S. economy. Capital formation is easy to stimulate—the Chinese government poured vast funds into projects—but consumer spending is harder to prompt. Stimulus worked in China in part because of the nature of the Chinese GDP; the failure to stimulate private consumption was part of the reason the U.S. recovery was, at best, tepid.

But the impact of these stimulus programs was broader and longer term than simply getting the overall economy pumping again. In oil, gas, and petrochemicals, billions of dollars in inexpensive loans and outright grants were made to the first-tier state companies, CNPC (with its operating arm Petrochina), Sinopec, and CNOOC, as well as smaller sums to national, provincial, and municipal oil/gas companies. The net result was to spur a sustained expansion of refining and petrochemical capacity rarely seen outside of a national emergency, such as a war, and to allow Chinese companies to continue their buying spree for overseas (mainly) upstream assets, when most private and state oil companies curbed spending in the face of the economic downturn.

Some of the longer term impacts of the Great Recession began to emerge by mid-2011. First is that stimulus perhaps worked too well, and that inflation had begun to loom by end-2010 as the biggest domestic macroeconomic problem. The Chinese government and central bank since then have been doing their best to cool down what has been seen as an overheated economy. Lower growth rates, at a more sustainable pace, were the new grand economic target.

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The impact of the stimulus has been enormous, with a large number of refining, petrochemical, and energy infrastructure (pipelines, port renovation, storage) completed and substantial capacity yet to be commissioned. From January 2010 to January 2011, Chinese base refining capacity expanded by 1.6 million b/d and topped 13.5 million b/d and by 2014, based solely on projects that have already begun, this market will add a further 2.0-2.5 million b/d. China's distillation capacity is roughly twice as large as that of Japan and South Korea combined and more than two-thirds the base capacity operating in the United States. The buildup in petrochemical capacity has been even more breathtaking. In the years 2009-2010, Chinese ethylene cracking capacity (olefins sector only) rose from 13.1 MM MTA to 15.5 MM MTA and should expand further to 19.5 MM MTA by 2014.

Looming overcapacity may impact either refining or petrochemicals, though we believe that a supply overhang will be far more likely in refining. Price controls and retail subsidies impact oil demand far more directly than petrochemical consumption (see section below). A strong case can be made—based on petrochemical use per person, petrochemical demand based on GDP, and petrochemical product use in some of the fastest growing sectors, such as vehicle manufacturing and processed food packaging—that still-to-be-commissioned olefin capacity will be utilized. It is unclear whether incremental refining capacity will run at a high utilization rate by mid-decade. Oil imports are a source of growing concern for central planners. For the first time in recent months, China exceeded the United States in its proportion of imports to total crude oil use.

There was substantial speculation in 2009-2010 that China would be the engine that pulled the world economy out of recession. These hopes have been dashed as China's domestic market—i.e., its portion of GDP that is based on private consumption—still was not large enough to alone pull China out of recession, let alone the global economy. Yet China's newfound economic importance has been underlined by its support of Asian economic growth. As the possibility of a double-dip recession loomed in mid-2011, it appeared that Chinese economic growth, albeit at a lower rate, would continue to support overall Asian growth. Yet China remained at base an export-oriented economy, as the 2008-2010 recession revealed. Once all export niches were filled, growth in China necessarily slowed.

Energy Subsidies

Yet it is the issue of oil, gas, coal, and power subsidies that perhaps most shapes Chinese energy use. The topic is vast and complex in China—a function of its transition to a market economy—and we can say in summary that while many subsidies have been rolled back or abolished, many others still continue and cause what energy economists characterize as the “structural deformation” of the Chinese economy. Decades of energy subsidies have created an economy based on high-energy intensity—i.e., the amount of energy needed to create additional GDP—and a major aim of government planners is to reduce this by 2020.

Oil prices in China were traditionally kept below average Asian levels, let alone world levels. Some products were only in part price controlled, allowing market pricing in certain sectors. LPG produced from onshore gas fields or refineries has remained price controlled, but imported LPG or LPG produced from offshore gas field could be sold at free market price. Yet overall prices were kept low, encouraging unnaturally high demand growth. This, as much as true general economic expansion, has been the primary driver in ballooning Chinese oil consumption.

But since the recession gathered pace, there have been signs of a reversal. From mid-2009 until late 2010, the consumer, on average, paid more for Chinese gasoline than that produced in the United States. Of course, despite the pretense that gasoline prices are set solely by a free market, U.S. transport fuels, too, have wasteful biofuel subsidies and a tax tariff policy that favors gasoline over road diesel use.

The Chinese government's current pricing system is basically a ceiling/floor mechanism linked to world prices through the Singapore spot market. However, the current mechanisms are too slow to respond to changing prices and often do not fully reflect the impact of price changes. Beijing is well aware of that—but as the government rides the tiger of subsidized oil demand growth, it prefers to try to reform the current system and avoid the twin dangers of popular unrest and stoking inflation, two likely impacts of a decisive break with the ceiling/floor pricing system. It should be noted that price distortion is a double-edged sword—price controls have kept China out of sync with both higher and lower world oil prices.

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The great gas oil squeeze of late 2010 illustrated the problems China has in moving toward a market economy while still setting macro-economic goals in Five-Year Plans. In October 2010, a number of provincial governments, under enormous pressure from Beijing to meet the national goal of cutting energy intensity by 20% in the 2005-2010 Five Year Plan, began limiting power consumption. This forced many businesses to shift to gas oil-based mobile power generation. The impact was particularly noticeable in provinces such as Zhejiang and Guangdong, where manufacturing activity had already begun to rise sharply by mid-2010. Across the Southern and Eastern Seaboards, old generators were recommissioned and new units purchased. This was the primary cause of a startling run on gas oil supply.

The large-scale refinery expansions of 2008-2010 were expected to create a gas oil supply overhang; instead, the central government created a near state of emergency and authorized all refineries—even illegal plants—to run at maximum capacity in order to plug the gap. By late October 2010, Chinese refineries were producing an incremental 170,000 b/d of gas oil/road diesel—roughly equivalent to 5% of national demand that month.⁵

There were, of course, secondary reasons for the sudden gas oil shortage, including delays in large infrastructure projects that year and booming export sales due to a shortage in European gas oil supply. But the gas oil affair illustrated what a tricky balance the central government must attempt in its transition to a market economy as well as how dangerous the current subsidy system remains for national oil supply.

It appeared in most recent government declarations that policymakers will back into free market prices through the issue of energy efficiency, with the unfortunate gas oil snafu of 2010 illustrating how not to proceed. The National Development and Reform Commission (NDRC) has issued regulations that will, over a period of time, close down inefficient petrochemical, refining, and other heavy industries that use excessive oil and gas. We expect that China's domestic oil product prices will gradually move to parallel world levels, just as over the past three years national gas prices have moved ever closer in step with world prices. The concept of closing down inefficient power generation was correct—it was the haphazard implementation to meet the deadline of a Five Year Plan, Beijing has concluded, that caused this supply shortage.

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While improving energy efficiency remains the goal, and moving to an alternative pricing system the means, by mid-2011, despite more than two years of discussions, China has been unable to improve its pricing system to better reflect energy costs and curb wasteful and inefficient consumption of oil and gas. A key concern behind this sustained hesitation to reform has been worries about inflation, with the government concerned that a more market-based pricing system would raise inflation rates, which peaked at a three-year high in June 2011. The government realizes that the current system cannot last much longer; yet its faith in the ability of markets to regulate prices remains minimal—and the NDRC, which sets policy and prices, often delays price increases for fear of stoking inflationary pressure for an overheated domestic economy.

Still, the NDRC has begun a limited experiment to make the current pricing system more reflective of and responsive to world prices. In August 2011, the NDRC began setting Jet A-1 (aviation fuel) prices monthly, with levels linked to the Singapore spot market—“a big step toward a market-oriented system,” according to the Chinese government bureau, and a precursor to reform of the other two transport fuels, gasoline and road diesel. Jet prices will be based on ex-refinery gate values and linked to Singapore spot quotes for the previous month. If successful, and if extended to other transport fuels, these measures could have significant impact on East of Suez spot markets—particularly in gasoline and road diesel, where Chinese consumption of a single product often has been greater than the total oil demand of many Asian markets. If China's product prices move closer in sync with world price levels, this too would reduce direct and indirect oil product subsidies.

II. Oil Products Demand: A Sector Analysis

What the Recession Did to Demand Growth

Recession hit China as hard as any other major market in 2008. Ultimately oil demand growth was slowed but did not stop. For much of the period 2008-2010, China remained only a relatively steady growth market, with a sustained rise in oil products demand beginning as early as the second quarter of 2009.

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China's relatively quick energy sector rebound from recession was due to a number of factors. Price controls, at least in the beginning of the recovery period, kept oil product prices below world levels, and this encouraged a quick consumption rebound in a rapidly urbanizing society that had many years of sustained, often breakneck, economic growth. The government's quick move to implement a large stimulus program in November 2008 worked far better than in Western economies, in part because private consumption in China made up so much less of the overall economy—no more than 25% of GDP, compared to roughly 75% in the United States.

Another reason for Beijing's relatively rapid rebound is that much more of its trade now is with Asia-Pacific economies, and not solely in the form of exports to the United States and European Union. Many of the smaller economies—Thailand, for example—pursued far tighter credit policies than Atlantic Basin markets, in part because of their disastrous experience in the Asian Contagion recession of 1997-1998.

A growing concern with inflation has led the Chinese government to try to slow its economic growth, even as Western markets record a slow and uneven rebound. It is important to consider that China alone will not rescue the world economy, and that growth, at least to some extent, is dependent on expanding export markets. But more important, at least in the medium term, are the many subtle changes that are under way in how China uses oil products.

It is interesting to note that in 2010, the big demand gainers among specific products in the Chinese demand barrel were essentially flat in most oil markets worldwide. In 2010, gasoline demand rose 5.9% (2.771 million b/d), naphtha 9.7% (907,000 b/d), and gas oil—powered mainly by rising automotive diesel oil (ADO) or road diesel use, but compounded by the end-year power generation squeeze—a remarkable 6.5% (2.977 million b/d). Despite the global downturn, Chinese petrochemical demand was still strong and naphtha use expanded rapidly on the commissioning of a number of major ethylene cracker projects. Aviation fuel use that year still rose 9.5%, in calculations by Asia Pacific Energy Consulting (APEC). Chinese use of Jet A-1 in transport rose to 251,000 b/d at a time when Western markets only just began to recover from the demand declines of 2009.

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As detailed in the introduction, substantial disagreement occurs, even among respected groups of China analysts, as to what should be emphasized in demand trends. Deutsche Bank in a February 2010 analysis forecast that overall demand growth that year would be around 7%, that only minimal demand growth would be seen in gas oil/road diesel (0.2%), and that fuel oil demand would rise by 5%. Naphtha and jet kerosene, two of the biggest growth products that year, were not even mentioned. APEC forecast growth at less than 6% in 2011 (demand rose 5.2% in 2010), despite a surge in naphtha demand. Even “experts” can see things differently.⁶

A major theme this decade is how barrel pressures will shift through 2020. Over the past decade, transport use of gas oil finally overtook industrial and power generation consumption. A major question will be whether road diesel or gasoline will be the future dominant land transport fuel—whether the dieselization of China is a continuing trend. A second trend that has taken many analysts by surprise has been the extraordinary growth of China's base petrochemical capacity.

Liquefied Petroleum Gas (LPG)

This product is truly unlike any other oil product, and in many ways it can be considered a feedstock as much as a final product ready for end-user consumption. On the supply side, LPG consists of propane (C3) together with butane (C4), consisting of three and four carbon molecules respectively, and is a natural gas liquid (NGL). NGLs are stripped from natural gas when the gas stream is processed for market. Yet LPG is also produced as a by-product of distillation, as LPG is the first product that turns to vapor when crude is distilled.

This is not the only characteristic that makes LPG unique among oil products. Unlike other products, it must be stored in pressurized or refrigerated containers; this means that LPG, unlike gasoline or fuel oil, must have its own specialized infrastructure for storage, transport, and distribution. This makes LPG expensive to move and implies that exports will take considerable capital investment should a producer want to sell output at any distance from the point of origin.

These LPG basics have substantial impact on China's LPG balance. Unlike major LPG exporters Saudi Arabia and Qatar in the Mideast Gulf and Asia Pacific's Indonesia and Australia, China derives most of its LPG supply from refining. Most Chinese LPG output is a function of refining

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and refinery utilization rates—even if Chinese refiners attempt to minimize LPG outturn, the sheer size of China's base refining capacity alone produces large volumes of LPG. Unlike any of these exporters, Chinese refiners cannot afford to invest in infrastructure to transport LPG, let alone store it for any length of time. They sell most LPG in the immediate local markets near refineries—and China is the largest consumer by far of LPG in Asia Pacific. In East of Suez markets it ranked second only behind Saudi Arabia as a producer, but still is a net LPG importer—129,600 b/d in 2010.

Chinese LPG demand also has been shaped by price controls. LPG produced in the domestic market is strictly price controlled; refiners often make minimal profits on its sale, and it does not pay to build specialized infrastructure to move LPG output any distance. LPG imports and LPG produced from offshore gas fields, however, can be sold at market price. This has led to the construction of limited infrastructure to receive and store products in coastal China, particularly in the booming Southern Seaboard provinces of Guangdong, Fujian, and Guangxi.

Due to price controls, most LPG sales are price inelastic; only imports, mainly in the Southern Seaboard, respond to market price signals as well as inter-product competition. Roughly 80% of LPG use in China is for cooking, heating, and lighting in the residential/commercial sector. Industry only makes up about 17.5% of demand and transport 2.5%. LPG use as petrochemical feedstock is minimal. China uses regional standard specifications, based on Saudi Arabian specs, and they differ only slightly from U.S. quality standards.

While full price decontrol remains only a future possibility, Chinese LPG use will still shift in the medium term.⁷ Piped natural gas represents a formidable competitor for the residential/commercial sector and already has made inroads into coastal sales of LPG. We expect that the cleanliness and high temperatures that LPG can produce will increase use in the metallurgical industry, in particular the manufacture of high-quality specialized grades of steel. The looming squeeze on petrochemical feedstock for olefins—petrochemicals that produce most basic forms of plastic—make it probable that LPG increasingly will substitute for naphtha in ethylene crackers. The limit on this is that LPG, either propane or butane, provides sufficient ethylene yield, but naphtha provides a far greater outturn for associated petrochemical

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intermediates and end products. Yet even if we forecast a rise in the industrial and petrochemical sector, it is likely that residential/ commercial consumption of LPG will remain at nearly two-thirds of total demand and that most LPG still will be consumed close to the point of supply.

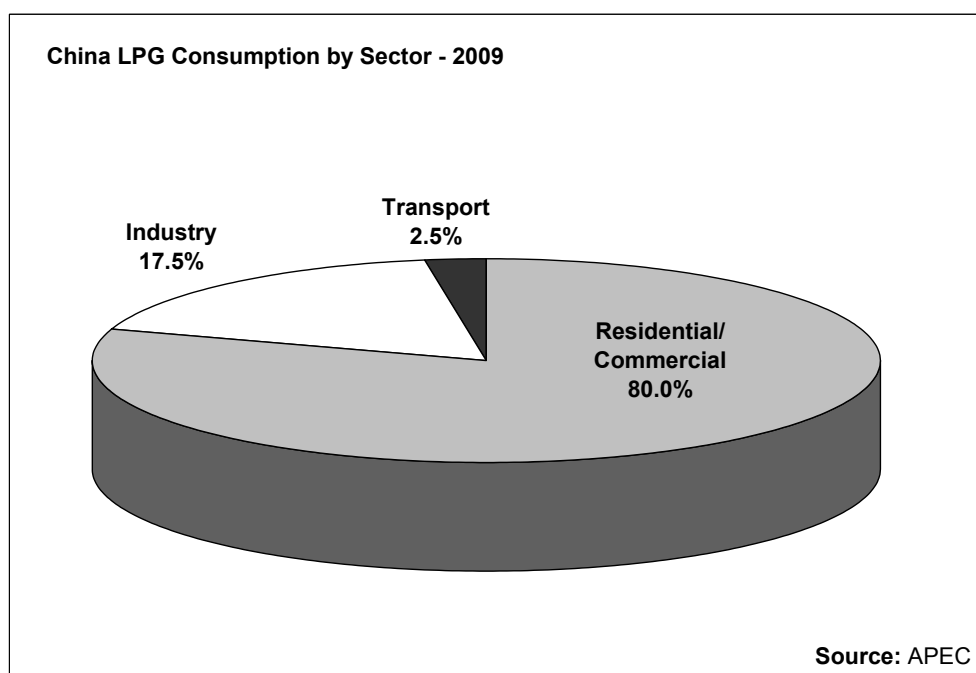
Supply will rise sharply on increased refining capacity as well as increased gas output in the domestic market. In 2009, gas production in China was double the output of 2005 and triple the production level of 2000. At least part of this gas will be stripped of NGLs; rising gas output makes it likely that field LPG will play a bigger role in Chinese supply.

Table 1. China LPG Balance (in thousands of b/d)

China LPG Balance					
Year	Demand	Output	<i>of which:</i> <i>Field</i>	Export	Import
2003	612.5	423.0	49.0	0.7	202.0
2005	703.0	515.0	82.4	0.8	192.0
2009	760.4	687.8	116.8	26.7	128.5
2010	783.9	702.3	126.4	11.4	140.0

Source: APEC

Figure 1. China LPG Consumption by Sector in 2009



Gasoline

Unlike LPG, gasoline is only used in one sector—transportation—and supply comes only from refining and blending. It is similar to LPG in that it competes directly against road diesel, a superior quality grade of gas oil used solely for transport.

China's gasoline demand growth during 2000-2010 was nothing short of stupendous, with the greatest gains in the first half of the decade. Demand growth was often in the range of 7% per annum. By 2006, China surpassed Japan as Asia Pacific's largest gasoline market.

Foreign analysts were enthralled by this trend and they focused on gasoline consumption as the main—if not sole—driver in China's explosive demand growth in recent years. They often paid little attention to diesel use because road diesel in Chinese statistics is not differentiated from overall gas oil consumption, and they often ignored other areas of extraordinary consumption growth, notably naphtha for petrochemicals as well as jet-grade kerosene for aviation fuel.

Many forecasts predicted wildly optimistic incremental gasoline use by 2020, in part because many assumed Chinese drivers and Chinese vehicles would be used exactly as they are in Western markets, in particular the United States. But cars are not used generally for commuting, as is the norm in much of the United States; nor are they regularly used for vacations, as is the case in much of Europe. A car represents, for the average Chinese family, the signal that they have arrived, and are a part of the country's growing middle class. Chinese cars are not driven an average 10,000 miles per year, as is assumed in the American market; they are not driven across the country, as there is no national limited-access highway system. Many Chinese cities, often with populations of one million or more inhabitants, are not even connected to the national highway system.

Yet the numbers were impressive. In 2003, gasoline demand was 989,000 b/d; by 2005, it rose to 1.110 million b/d; even with slower growth rates it rose to 1.229 million b/d by 2009, and last year topped 1.5 million b/d (1.502 million b/d), accounting for 18% of all Chinese oil consumption.

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While demand growth has moderated somewhat in recent years, a number of fundamental supports will underpin the continued expansion of Chinese gasoline demand, albeit not at the volumes traditionally forecast. They include:

An Emerging Middle Class: As in India, even if a relatively small percentage of households hit the magic take-off point for private vehicle ownership—something in the range of \$6,000-\$7,000—the purchase of a car is often the sign that a family has achieved this new economic status. In China, the emerging middle class numbered in the hundreds of millions by 2010.

Urbanization: In the countryside, incomes were lower on average; many people still shared agricultural machinery, long after collectives were abolished, and vehicles such as tractors were often used for transport as much as for farming. The growing number of people moving to cities has meant increased vehicle use, and in particular, increased trucking and private vehicle ownership.

Gasoline-Powered Cars: For decades, the government has attempted to restrain gas oil demand growth by restricting the use of diesel-powered vehicles. The policy appeared to be easing with the opening in Pudong (an industrial suburb of Shanghai) of China's first plant to manufacture diesel engine cars. Yet Beijing subsequently turned back to the near-exclusive manufacture of gasoline-powered vehicles, supplemented by hybrids and electric battery automobiles. This means that gasoline growth will be based on cars and road diesel growth overwhelmingly on trucks.

Smaller Cars, but Many More Drivers: As of January 2009, the total number of cars registered in China rose to more than 24 million; total vehicles numbered more than 50 million. Automobile output topped 10 million and exceeded that of the United States for the first time. Yet exports were minimal—less than 400,000 units and compacts and subcompacts dominated domestic sales. The non-automobiles sold used diesel; only cars ran on gasoline. Even with the expectation of a continued period of sustained economic growth for the next half-decade, the total number of vehicles in China will only reach 100 million by 2015—roughly one-quarter that of the American driving market. We concur with a forecast made by the FGEnergy

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consulting group in late 2010; even if its forecast of an average 4.6% growth through 2020 proved correct, total gasoline demand would rise to 2.5 million b/d, still less than one-third of current American consumption.

Slowing Demand Growth?: Despite a strong year of demand growth in 2010, we believe that this projection may in fact be slightly too high. Many energy analysts forget the role of government in setting tax/tariff policy on road fuel use. While the government cannot prevent ownership, it can discourage use. Chinese auto sales have shifted strongly to subcompact and compact models; big retail subsidies for hybrid cars and alternative fuels will certainly continue to eat into potential future gasoline demand growth. If the government (both central and local) discourages car use by increasing gasoline taxes, restricting vehicle registration, limiting car access to urban centers, or levying punitive taxes on larger engine vehicles, there may well be a shift back to smaller diesel cars—even if they must be imported—as well as alternative fuel vehicles. Since mid-2009, Chinese gasoline prices—even without punitive consumption taxes—have been close to, if not above, U.S. average retail gasoline price levels. We anticipate a strong, long-term expansion of Chinese car ownership, but unlike many analysts, we think this does not strictly translate in a linear fashion solely to gasoline demand. And if gasoline quality continues to tighten (Chinese gasoline specs remain below most Asian markets but have improved substantially since 2000), the cost of producing better quality gasoline—and cleaning up China's cities—will likely be borne by motorists.

More Stringent Efficiency Standards: China's automobile efficiency standard is the equivalent of 32 miles per gallon. Unlike the Environmental Protection Agency (EPA) rating system, each car is tested to meet this standard. In the United States, the standard is met on the average efficiency of an entire vehicle fleet—there is considerable wiggle room to defeat the aim of efficiency standards. Chinese cars with engines of up to 1.5 liters capacity are lightly taxed; cars with engines of 3 liters or greater have a punitive levy.

Table 2. China Gasoline Balance (in thousands of b/d)

China Gasoline Balance				
Year	Demand	Output	Export	Import
2003	989.1	1,129.0	176.0	-
2005	1,109.5	1,212.0	133.4	-
2009	1,418.7	1,715.5	117.8	1.1
2010	1,502.4	1,770.7	84.3	2.6
Source: APEC				

A note on product balances:

Product balances rarely “balance” out to zero, or nearly zero, as some product must always be exported as surplus to the needs of a market and some product imported in order to meet domestic demand. In China, without regular official statistics for either stocks or demand, the problem is exacerbated by factors of geography and logistics. It is less expensive to import products to the Southern Seaboard, often from abroad, than it is to ship products from northeast China in smaller tankers. Further complications come from the many different grades in each product group and their differing utilization. Chinese refiners usually export paraffinic naphtha yet almost always have to import at least some N+A grade to increase gasoline output. Similarly, refiners normally have to export regular volumes of lesser quality kerosene grades, while China has an absolute need to import Jet A-1 kerosene for aviation fuel.

Naphtha

Naphtha, a semi-finished product, has been the unsung star of Chinese oil products demand over the past decade. In 2003, naphtha only accounted for 7% of the Chinese demand barrel; by 2010, this grew to 11.2% of the whole. In 2000, China accounted for less than one-tenth of regional naphtha demand; in 2009, it made up nearly one-fifth of total regional demand. China's 15.5 MM MTA in ethylene cracking capacity as of January 2011 was almost equal to that of the two largest Mideast Gulf petrochemical exporters, Saudi Arabia and Qatar. It is likely that Chinese naphtha demand this year will exceed Japan's, in part due to Tokyo's twin natural disasters of tsunami and earthquake. Yet even using conservative projections, China is likely to gain the top spot as Asia's leading naphtha consumer by no later than 2013, when it should overtake South Korea.

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While most naphtha demand is in the petrochemical sector, either for olefins production (mainly plastics) or aromatic petrochemicals (styrene, resins, and polyester), characterizing it solely as a petrochemical feedstock ignores the many uses for this product. All gasoline is blended, using first a base stock of naphtha. Naphtha can be used in gas turbines for power generation; when run through a reforming unit, naphtha provides a vital component for gasoline blending, reformat.

But in China, naphtha has been the major petrochemical feedstock, in particular used as the base material for the ethylene cracking that has supported this product's extraordinary growth. Sinopec, one of the "Big Three" of Chinese oil, is by far the dominant petrochemical company. In the 1990s, Sinopec began to refurbish its old plant, expanding many ethylene crackers; more important, it modernized furnaces and converted design to accept mainly naphtha feedstock. This prompted a sustained rise in naphtha demand—a growth that accelerated mightily after 2000, when Chinese planners allowed Sinopec, as well as CNPC and to a lesser extent CNOOC, to build massive petrochemical complexes cross-integrated with refineries. The stimulus programs of 2008-2009 kept the momentum going. By January 2011, ethylene cracking capacity was nearly 3.5 times larger than capacity in 2000.

As naphtha continued overwhelmingly to remain the petrochemical feedstock, fears of a light products squeeze loomed, with competition growing between naphtha and gasoline for a limited volume outturn. This, as much as the need to meet national road diesel demand, has been the driver behind China's massive buildup in refining capacity since mid-decade. We expect that China will continue to lead the region in adding new refining capacity at least through 2015 and likely through end-decade.

Unless planners push petrochemical operators to use a broader mix of feedstocks, China may become a consistent net naphtha importer by 2020. The government has considered various options such as encouraging petrochemical plants to use LPG as a feedstock, building more condensate splitters that create a disproportionate volume of naphtha and gasoline, and introducing direct crude processing for ethylene cracker complexes. But no single program has yet been chosen. Companies have been reluctant to switch from naphtha in part because naphtha is price controlled, and alternative feedstocks may be sold on free market pricing. It is notable

that in 2009 China moved solidly into a net import position for naphtha for the first time in decades, although this was driven partially by the need to import naphtha grades to increase gasoline output.

Table 3. China Naphtha Balance (in thousands of b/d)

China Naphtha Balance				
Year	Demand	Output	Export	Import
2003	386.3	408.0	26.0	5.0
2005	522.4	549.0	42.0	8.1
2009	842.9	827.5	19.8	61.4
2010	924.7	907.3	21.6	63.0
Source: APEC				

Kerosene/Jet A-1

Kerosene has a wide range of uses in Asia Pacific and in some markets remains a major area of consumption for residential/commercial cooking and lighting (India, Pakistan, and Indonesia) and for heating (Japan). Most advanced economies abandoned using kerosene for these purposes decades ago; China is unusual as a developing country market in never having encouraged kerosene use in these sectors, but lesser-quality kerosene grades are commonly utilized in petrochemicals as solvents.

The real story in kerosene has been the breakneck growth in the use of high-quality Jet A-1 as aviation fuel. In 2000, aviation fuel demand barely topped 100,000 b/d and accounted for slightly over half of Chinese kerosene use. By 2010, jet consumption was nearly 251,000 b/d, and made up more than three-quarters of national demand for this product group. In 2009, China's aviation fuel use for the first time topped Japanese demand. If Hong Kong's consumption were included, China's use of aviation fuel would be greater than Japan and South Korea combined.

From 1990-2005, China's aviation jet demand averaged 14% growth per annum and while the 2008 recession reduced air travel in this market as elsewhere across the region, demand never fell. Instead, it only grew more slowly and ranged between 4.5%-5% in 2007-2009 and then rose sharply by 9.4% in 2010. We expect aviation fuel demand will continue to rise at a minimum 11%, with incremental demand growth concentrated in the first half decade.

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Unlike most other products, Chinese planners decided long ago that domestic refineries could not easily satisfy total aviation fuel needs. The trade pattern has been that substantial volumes of Jet A-1 were imported for domestic use, while a large volume of lesser-quality kerosene grades were exported. Since only a narrow temperature range can be used to create Jet A-1, even though Chinese refining capacity will continue to expand significantly through 2020, China will remain a net aviation fuel importer.

We expect that if our forecast for Chinese aviation fuel demand growth proves out, China's consumption of this product will likely equal the next three or four regional aviation fuel users combined by 2015.

Table 4. China Jet/Kerosene Balance (in thousands of b/d)

China Jet/Kerosene Balance					
Year	Demand	of which: Jet A-1	Output	Export	Import
2003	204.7	125.0	183.0	40.0	41.0
2005	266.0	169.0	243.0	58.9	72.0
2009	313.0	229.4	324.1	130.2	134.1
2010	328.2	251.0	368.3	133.3	129.1

Source: APEC

Gas Oil/Road Diesel

While its share of the overall demand barrel has eroded in recent years, gas oil (including road diesel) remained the largest volume product group in China's 2010 consumption, accounting for more than one-third of total oil product use. To give some idea of the enormous volumes involved, China's gas oil demand in 2010 was larger than total national oil use in every East of Suez market other than Japan. Its road diesel demand of 1.637 million b/d was 50% greater than that of India, Asia's second largest consumer.

This is an impressive figure and suggestive of the broad influence that gas oil plays in overall Chinese oil products use. And since Chinese statistics make no differentiation between lower-quality grades used in industry, power generation, and bunker versus better-quality true road

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diesel, this has led to considerable confusion among many analysts trying to detail the mechanics of China's oil product use.

Gas oil was the original choke point of Chinese supply and demand. While kerosene, the product group lighter than gas oil, was in surplus, fuel oil traditionally was short in the domestic market. Refiners could only widen the temperature range so much to maximize their output of gas oil—and better-quality road diesel was more difficult to produce. The government allowed substantial imports of residual fuel, particularly into southern China, until relatively recently.

What shifted though, was sectoral demand for gas oil. Unlike Western markets, where road diesel has for decades made up the vast majority of gas oil used (hence the American habit of calling gas oil “diesel,” when diesel is simply a subgroup within gas oil), China used more of this product for non-transport sectors than land transport. Only in 2008 did road diesel finally make up a majority of gas oil use. Since then, general gas oil use—outside of exceptional periods such as the end-2010 products squeeze—declined, while road diesel demand growth accelerated, mainly because the Chinese rail system has been unable to catch up with the need to transport ever-growing volumes of coal. By 2010, APEC estimated, road diesel made up roughly 55% of gas oil consumption.

Not only did road diesel become a majority of gas oil use, it also outpaced gasoline use in the overall demand barrel. In 2010, in absolute volume demand road diesel was 1.637 million b/d versus gasoline's 1.502 million b/d. This is fairly close as comparative shares of overall demand—19.8% vs. 18.1%—but this has been a considerable turnaround from the beginning of the past decade, when gasoline consumption was 15%-20% greater than road diesel.

Why these two big sectoral shifts? For the shift of gas oil demand from stationary utilization to transport, the reason is clear: China's move to using more natural gas in industry and power generation, both piped gas from domestic production and LNG imports, particularly for the Southern Seaboard. This has slowed demand growth over the past decade for general gas oil grades; it was the power generation debacle that caused a surge in general gas oil use at end-2010.

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The substantial growth in road diesel has been due to the shifting of coal transport from the overburdened rail system to shipment by truck—and all trucks in China use diesel, not gasoline. From 2006-2010, road diesel use rose 456,400 b/d, or nearly 39%, as trucks transported coal to landlocked power plants and industries.

The big question is whether this “dieselization” of Chinese land transport will continue. The government remained committed to using gasoline as the main conventional fuel for vehicles in 2010, though it has been trying to increase gasoline volumes through the use of methanol as well as ethanol, and encouraged alternative and renewable fuels as well. The Chinese rail system has continued a massive overhaul of the entire network, but appears to have made little progress in catching up with growing transport needs for additional coal. If rail capacity increases faster than coal use, then it is likely that dieselization will falter—and gasoline will reclaim its role as top land transport fuel. That may come as welcome news. In 2010, the government began a program of steadily improving mandated road diesel quality, and Chinese refiners may have difficulty keeping up with tightening specs. Yet for now this is the less likely scenario and we see, at least through mid-decade, road diesel demand steadily expanding.

While natural gas has tended to cap non-transport gas oil use, recent events (as outlined in the government intervention section above) showed how easily changes in government policy can impact oil products demand. We expect moderately strong demand growth in gas oil to continue and that it will be concentrated in road diesel, rather than industry or power generation. A major exception will likely be the use of marine gas oil and marine diesel as ships fuel or bunker. In this subsector, gas oil has grown enormously in the past decade and was estimated at more than 76,000 b/d in 2010. If international bunker regulations restrict the use of high-sulfur fuel oil for China's vast—and growing—export trade, we could see a massive boost to gas oil use in this sector by 2020.

Table 5. China Gas Oil Balance (in thousands of b/d)

China Gas Oil Balance					
Year	Demand	of which: Road Diesel	Output	Export	Import
2003	1,998.9	865.0	1,922.0	46.0	22.0
2005	2,265.0	1,083.0	2,416.8	29.7	10.7
2009	2,795.4	1,509.5	2,897.2	90.8	37.0
2010	2,977.0	1,637.4	3,141.0	97.8	32.5
Source: APEC					

Fuel Oil

Traditionally, the Chinese market has been short of fuel oil and has had to import large volumes of this product, particularly in the thriving Southern Seaboard. Residual fuel from refineries was often supplemented by direct burning of crude—a practice that has dwindled to small volumes, as China has imported ever greater volumes of crude, but has not ceased.

Fuel oil also has been the only major product without any mandated product quality minimums. Chinese residual often contains sulfur, metals, and other impurities far greater than the norm for Asia Pacific, and while lesser-quality material is often blended into the bunker pool for use as ships fuel, this “sump” for poor-quality fuel oil may disappear as international bunker specs tighten.

Fuel oil use in China has focused mainly on power generation, particularly in the Southern Seaboard, and in light industry mainly in areas where coal cannot be easily used as either process for heat or for space heating. China's increased use of natural gas has more or less capped demand at about 800,000 b/d in 2010 and we expect a slow further decline by 2015.

The major growth area, however, has been in bunker sales, which have expanded steadily and since 2005 averaged at least 6% growth per annum. Yet overall we expect a continued backing out of fuel oil use by gas and more or less steady demand in the 800,000-900,000 b/d range through mid-decade, with imports making up for domestic shortfalls. A major concern in the fuel

oil balance has been the use of residual as bunker. Chinese demand figures often underestimate the volume of bunker, which approached 200,000 b/d in 2010, driven by booming exports.

Table 6. China Fuel Oil Balance (in thousands of b/d)

China Fuel Oil Balance				
Year	Demand	Output	Export	Import
2003	759.0	413.0	12.0	437.0
2005	871.0	552.0	40.1	455.8
2009	836.4	744.8	113.5	365.3
2010	800.4	467.0	168.5	393.6
Source: APEC				

Products Use: A Summary

The traditional key pressure was between producing enough gas oil/diesel, while meeting fuel oil needs (power, bunker, and industry) as well as kerosene (mainly jet, but also general grades for solvents). Despite natural gas capping general gas oil demand, growth in diesel use has more than made up for the slowing of general gas oil incremental demand. Further, a second substantial pressure point has emerged between gasoline and petrochemical feedstocks for light ends outturn. Chinese refineries limit their plant LPG output and try to limit upper-end kerosene production, so long as it does not cut into jet outturn. Yet the slowing growth in incremental gasoline demand has been more than matched by the ballooning growth of incremental petrochemical feedstock demand, both for olefins and aromatics. With piped gas feedstock (ethane) far in the future and only limited direct-feed use of condensate and LPG, naphtha is caught between pressures from the transport sector and petrochemicals—and this looks unlikely to ease in the medium term.

What this means to regional, and indeed global, products balances is that Chinese crude imports will continue to expand. China has been for some years the largest crude importer East of Suez, but planners hope to meet most, if not all, product needs from domestic output. Product exports will be a function of what China cannot use, rather than an aim in and of itself. Yet if refining capacity expansion outpaces domestic demand growth—and this is a distinct possibility—product exports will shift from small volumes of lower-quality gas oil and general grades of fuel oil to a full range of products. And since it would appear that the world's second largest single

oil market will continue to grow at least moderately throughout the decade, this will impact Asia Pacific and the world.

This section detailed the nature of Chinese oil use. The following section reviews how conventional refining met China's products demands in the past and China's efforts to use coal-to-liquids (CTL), gas-to-liquids (GTL), and unconventional gas as alternatives to meet future energy needs.

III. Oil Refining and Synthetic Oil Alternatives: Future and Forecasted Capabilities

Some basic themes have remained remarkably steady for China's oil downstream sector in recent years: a steady and broad-based expansion of total refining capacity; an enormous growth in crude imports as Chinese domestic production has been unable to keep pace with incremental refining needs; a continued program to increase product quality; and the exploration of alternative means, using natural gas and coal, to create synthetic oil and petrochemical products.

Yet despite the tremendous growth in Chinese refining capacity, we expect the sector to remain focused on the domestic market, avoiding exports other than those products that do not fit into home market needs. We have been using base or distillation capacity as the measuring stick for Chinese refining capacity, but in reality Chinese refineries have been adding massive new capacity across the board, including severe cracking and quality improvement units such as hydrotreaters and hydrocrackers. Refining capacity is not only much larger in 2011 than in 2005, but also substantially more sophisticated.

A regular announcement made by the central government has been its determination to close down undersized, antiquated, heavily polluting refineries that often have been operating for years without permits. Since this illustrates much about the limits of government power, even in a market accustomed to centralized planning dictates, we will examine this area first.

In March 2011, Beijing announced its latest drive to rationalize refining capacity, with the NDRC declaring that all refineries of under 40,000 b/d base capacity will have to expand and

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upgrade by 2012 or close down. All new refineries will have to have base capacity of at least 200,000 b/d; severe secondary capacity, including fluid and residual catalytic crackers and hydrocrackers of at least 30,000 b/d, reformers of a minimum 20,000 b/d, and ethylene crackers will have a minimum 0.8 MM MTA capacity. The question is whether these measures will be implemented. They were not in the past.

In 2009, the NDRC decreed it would close down low-efficiency, low-quality refining plants of less than 20,000 b/d by 2011. As was the case in early 2011, the top government planner said it would force the closure, consolidation, or expansion of all plants under that minimum capacity. The 2009 measure was largely ignored.

A late 2010 estimate by the China Federation of Industry and Commerce listed more than 60 small private refineries with a total base nameplate capacity of over 1.62 million b/d, or just under one-fifth of official base refining capacity of 8.1 million b/d. APEC's estimate as of January 2011 was that total base capacity in China was 13.5 million b/d.⁸

The existence of so many plants of dubious legality has serious impacts on the completeness and accuracy of Chinese oil statistics. No one—including the government—knows at any time what the total base capacity of the market is; no one has any idea of the average volume of throughput, and no one has a complete picture of stocks. This is a fact of life in looking at Chinese oil. And efforts to close down these plants undersized and inefficient plants, known as “teapots,” have so far failed. The central government has restricted its crude and fuel oil imports, its use of oil pipelines and rail transport, and imposed a higher tax on fuel oil used as feedstock, but all of these measures have proved ineffective so far. The seriousness of this problem can be gauged in Table 7, which is based on APEC's work in Chinese refining. APEC grouped together all “teapot” refineries of less than 30,000 b/d into aggregate numbers, further broken out by the two major regions for these small plants. The slight decline in total “teapot” base capacity between 2009 and 2010 came from the expansion of a number of smaller downstream complexes, which topped the 30,000 b/d threshold. Literally thousands of micro-refineries of less than 1,000 barrels a day capacity have been excluded.

Table 7. China Base Refining Capacity (in thousands of b/d working capacity)

China Base Refining Capacity			
	Jan-09	Jan-10	Jan-11
Total	10,808	11,898	13,517
Teapot	1,661	1,631	1,693
<i>of which: Shandong</i>	553	455	576
<i>of which: Guangdong</i>	281	309	280
Teapot %Share of Total	15.4%	13.7%	12.5%
Source: APEC			

Essential Orientation Toward the Domestic Market

Though both CNPC and Sinopec have ventured into downstream abroad, the essential orientation still is toward the domestic market. This is a contrast to India's export ambitions. Security of supply has been seen as the main driver in China's acquisition of a vast array of foreign upstream assets as well as for Beijing's push to complete multiple oil and gas pipeline projects to feed Beijing's future appetite.

Yet this concern has also been one of the main supports for the completion of an enormous increase in Chinese refining capacity. It is striking that China has added, in a relatively short period of 2008-2011, not only more than 3.52 million b/d of distillation capacity but also 2.85 million b/d of intermediate units (quality improvement capacity) and more than 2.5 million b/d of severe secondary capacity. This allows Chinese refiners not only to process more crude, but also to produce a higher proportion of lighter products of better quality, or possibly run a wider range of lesser quality crude.

Table 8. China Historical Refining Capacity (In thousands of b/d working capacity)

China Historical Refining Capacity							
	Jan-08	Jan-09	Jan-10	Jan-11	Jan-14	%Change	
						2008-2011	2008-2014
Base	9,927	10,808	11,898	13,517	15,767	36.2%	58.8%
Secondary	3,786	4,766	5,814	6,303	7,035	66.5%	85.8%
Intermediate	1,863	2,426	3,303	3,841	4,608	106.2%	147.3%
Source: APEC							

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China and India have accounted for more than three-quarters of all refinery additions in Asia Pacific since 2008. Since recession struck Atlantic Basin markets far harder than East of Suez markets, the two often accounted for well over half of all worldwide refinery add-ons since 2008.

Yet there is a fundamental difference between these two Asian demand giants. China has been building refining to feed its fast-growing domestic market; India has been expanding refining to increase product exports.

China's Recent Refining Capacity Buildup has been Breathtaking

Base refining capacity in 2011 was more than twice as large as in Japan, the Asia-Pacific leader for decades. From 2000 to 2005, China added 1.641 million b/d base capacity and 1.259 million b/d severe secondary capacity; in 2005-2010, China added 5.734 million b/d base capacity and 3.155 million b/d severe secondary capacity. Yet this should be kept in perspective. As of January 2010, China's refining capacity was 67.2% of that in the United States and it was far less sophisticated.

It is extremely unusual for any market to add on this much refining in so short a time, short of a national emergency such as a war. Yet this must be put into relative perspective. As of January 2010, according to the Oil and Gas Journal's annual refinery survey, the United States had 17.7 million b/d of refining base capacity and 9.76 million b/d in coking, catalytic cracking, and hydrocracking capacity—roughly 50% more distillation and more far more severe cracking capacity than China. U.S. refining is still far larger and far more sophisticated, but China has added much capacity to its downstream in a very short period of time.

The next largest Asia-Pacific refiner, though, will continue to be Japan. (Please note that we have used refining capacity prior to the 2011 natural disaster, which damaged some Japanese refining capacity.) While Japanese refining remains more sophisticated overall than China's downstream, a combination of Chinese expansions and Japanese plant closures has greatly widened the gap between the two markets' working capacity. As of January 2010, Japan's base and severe secondary capacity were only 39% of China's working capacity, though Japanese refineries' severe secondary capacity as a proportion of distillation was slightly higher at 29.8% to 27.8%.

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Only in units that improve product quality (known as intermediate refinery units) did Japan still show a marked advantage over China. Combined hydrotreating and hydrodesulfurization operated by Japan totaled 5.5 million b/d, compared to China's 3.3 million b/d on a much larger base capacity. To put this into a regional perspective, Chinese refining alone accounted for 37.5% of all base refining capacity in Asia Pacific and nearly one-third (30.5%) of all refining East of Suez.

To feed that refining capacity, a lot of crude is needed. While domestic production rose faster than expected in 2010, most incremental crude needs were met last year by imports. Crude imports set a record at 4.79 million b/d, a rise of 17.5% over 2009 levels.⁹ China in 2010 imported more crude oil than Japan, South Korea, India, or any single European market. China, like the United States, has become an arbiter of the international crude oil barrel, with substantial impact on world prices and oil trade flows. From the Chinese perspective, this crude import dependency has become a growing concern. China's Ministry of Information and Industry in August 2011 highlighted that the country's dependence on crude imports surpassed that of the United States in the first five months of 2011, reaching 55.2%, compared to American import dependence of 53.5%. Independent calculations showed that crude imports made up nearly 56% of crude use in the first half of 2011. This will only grow in view of government forecasts predicting runs will rise by 8.5% in 2011 to reach 9.24 million b/d.

This influence will only grow though, unlike many Western analysts, we do not believe the theory that Chinese demand has been the prime driver in moving international crude prices above \$100/barrel (BBL). The NDRC in 2009 predicted that domestic output would peak by 2020 at 220 MM MTA, roughly 4.4 million b/d. That means that imported oil will have to make up the balance and would account for two-thirds or three-quarters of Chinese refinery slates by end-decade. What gets the geopolitical thinkers nervous is that Saudi Arabian crude has been growing in importance to Chinese supply needs—as it has to Western buyers—and it is likely that the kingdom's share of Chinese crude imports will grow from the average 20%-25% seen in 2009-2010. Chinese demand was definitely a support for higher crude prices, but alone did not prompt the rise.

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China and India will account for three-quarters or more of refinery additions through 2015 in Asia Pacific. Together, China and India will dominate refinery expansion through 2020 in Asia Pacific. Some essential differences in refining have emerged between China and India, and they are indicative of different approaches to meeting future product needs across the region.

Rationalizing Plants

Both countries have had to deal with undersized and antiquated refineries and it has been more difficult in both to shut down old plants than to build new ones. While China tried to shut down semi-legal mini-refineries and micro-refineries in 2005, 2009, and again in 2011, the government met with little success; but it has had limited success in encouraging expansion to minimum capacity and upgrading smaller refineries. India actually operates some of the oldest refining units in the region. Parts of its Assam refineries were built by the British in the late 19th century, but the problem of undersized plants that process often unrecorded oil products has been far more pressing in China.

Upgrading Old, or Building New Refineries

China has been far more successful than India in building grassroots refineries over the past decade, but it must be noted that the privately owned Reliance complex at Jamnagar operates the most sophisticated refinery in the region, with a complexity that easily exceeds Zhenhai, the most sophisticated plant in China. The drivers have been slightly different in China and India. India focused on upgrading existing refineries as its priority, while for much of the past decade grassroots projects were continually delayed. Meeting fast-tightening product specs, particularly for road diesel, was the primary concern of refiners. In China, the prime imperative has been striving to keep up with a sustained period of breakneck demand growth running across the demand barrel, and the main consideration has been meeting domestic needs.

Pace of Improving Product Quality

A further factor shaping refinery investment has been the need to provide a better quality product. This will be detailed further in the following section, but overall India has tended to emphasize product quality, particularly in gas oil/road diesel, to a far greater extent than China. Though Chinese specs have begun to tighten sharply in 2010-2011, they remain looser than the

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Asia-Pacific norm. India began to install distillate HDT and VGO hydrodesulfurization units—which can remove most sulfur from road diesel—as early as 2007 and retrofitted most of its middle distillate hydrotreaters by 2009. China only began to tackle this issue of road diesel quality in 2010-2011 by commissioning similar capacity.

The Need to Improve Quality and Demand

China needs to improve product quality and meet gasoline, road diesel, and naphtha demand, underpinning steady expansion of quality improvement units (intermediate) and severe secondary units (R/FCCs, HDC, Coking). First, a word of caution: When Asian governments claim that they have met the product quality standards of the European Union (EU), often called “Eurospecs,” this compliance is selective and uneven. For example, when China adopts Euro-III specifications for gas oil/road diesel, these quality standards will meet EU requirements for sulfur and ignition value (i.e., cetane), but will differ substantially in secondary quality points as well as allowable aromatics (polyaromatics, or PAH), a major contributor to air pollution. This applies to Chinese gasoline as much as to gas oil/road diesel and is by no means unique to Beijing. Indian products also fall short of the Eurospec standards they claim.

That said, China has made an enormous effort to clean up its act figuratively and literally in oil product quality. The 2008 Summer Olympics were a powerful incentive for the government in Beijing to implement—and more important, to enforce—tighter product specifications, just as the 1988 Summer Olympics were the spur that drove South Korea to begin serious improvement of its oil product quality standards.

What has been most interesting in China is that spec-tightening has focused on gasoline, which until recently made up the majority of fuel used in land transport. Despite gas oil's traditional dominance of the Chinese demand barrel, Beijing lagged behind India substantially when it came to improving gas oil and road diesel quality. While the Indian focus on road diesel quality has been understandable from Delhi's perspective, it is only recently that road diesel specs have been tightened in China, which imposed limited PAH caps in 2009 and reduced sulfur to 50 parts per million (PPM) maximum in 2010.

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Yet the tightening gas oil and road diesel specs, which began July 1, 2011, will have a substantial impact. Chinese refiners are expected to absorb the additional cost of providing better quality road diesel and have little financial incentive to invest further for other improvements in product quality down the road. While the new road diesel will have the Eurospec-II ceiling of 350 PPM for sulfur, general gas oil will remain fairly high in sulfur at the allowable 2,000 PPM ceiling.¹⁰ Nor do the new standards comply exactly with Eurospec-II standards—many of the secondary quality points mandated differ. Yet an important decision has been made: For the first time, PAH caps have been applied nationwide. These new, stricter quality standards for gas oil/road diesel, as well as continued tightening of gasoline specs, have been the chief driver in adding enormous new intermediate unit capacity.

Just as spectacular as China's fast-track expansion of refining has been its enormous buildup in base petrochemical capacity. Chinese ethylene cracking capacity doubled in the period 2000 through 2007 and has again doubled to at least 15.5 MM MTA (we have excluded CTL-based projects that have been only test-running) as of January 2011. Since 2008, a half-dozen grassroots plants have started up in China, and a further half-dozen are under consideration.

And the expansion is not over. As detailed earlier in the oil products sector use section, we expect ethylene cracking capacity to expand still further. APEC estimated, in a conservative forecast, a further 4.0 MM MTA of ethylene cracker capacity will be commissioned by 2014, and a dozen other proposals have been floated.

Saudi Arabia and China Add Bulk of New Ethylene Cracking Capacity Through 2020

While eyes have been focused on the Mideast Gulf petrochemical exporters Saudi Arabia and Qatar, which together have commissioned nearly a half-dozen new olefins complexes in recent years, far less attention has been paid to the impressive Chinese ethylene cracker buildup that added six new grassroots plants in 2009-2010. Among the large international petrochemical companies now operating ethylene crackers are Dow, Sabic, BASF, and Exxon Chemical. Beyond the 4 MM MTA in new capacity that will likely start up by 2014, China may see additional grassroots olefins plants funded by BASF, Dow, Shell, KPC, and QP by the second half of this decade.

China as Oil Products Exporter?

APEC takes a very conservative approach to forecasting new refining capacity, and our projections generally are lower than many Western analysts. But even if only half of our projects under consideration as possible new plants in our longer term outlook are commissioned by 2016-2020, that would add a further 1.74 million b/d in base capacity. We do not expect that all this incremental capacity will start up in that time frame. Many projects have been delayed repeatedly and many proposals are simply floaters meant to test government reaction, but it is clear that the Chinese refinery buildup will continue post-2015. We believe it unlikely that China will turn to products exports in a concerted fashion, at least through 2020.

Petrochemical Imports and Regional Exports

It was the China market that helped support Asian petrochemicals through the darkest days of the recession of 2008-2011 and Chinese imports of naphtha, finished and semi-finished petrochemicals, and ethylene that created a fairly steady outlet for Asian exporters, notably South Korea and Singapore.

Yet by 2011 there was increased concern as to how much longer this would last. We have earlier detailed the enormous buildup of China's ethylene cracking capacity. While China's demand growth for basic petrochemicals will remain at least moderately strong for the medium term, it will not continue to absorb all of the incremental exports that will emerge from the Mideast Gulf, India, and Southeast Asia forever. If China decides, as the government often aims to, to supply almost all of its own petrochemical needs, then some serious regional imbalances may well emerge by 2015. Yet for the immediate future—and a great comfort to petrochemical exporters in the Mideast as well as Asian exporters—China will continue to import ethylene, semi-finished petrochemicals, and naphtha.

There have been growing fears in 2011 that global inflation, driven by high oil prices coupled with the overheating of China's economy due to economic stimulus packages, may trigger a decline in commodity-based demand for both oil products and petrochemicals well before 2015. A sustained period of high oil prices may cut into future demand and make newly expanded refining and petrochemical capacity surplus. It should be noted that every time since the 1970s

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that oil prices rose for a sustained period above a constant 1970s \$50/BBL range, oil product and petrochemical demand fell. Why should China be different now?

Petrochemicals diverge from general oil use in forecasts simply because, despite growing substantially richer over the past two decades, China uses on a per capita basis far less plastics, polyester, styrene, and resins than the average industrialized economy. If one took Japan's use of an intermediate petrochemical product such as high density polyethylene (HDPE) and applied it to China, Chinese ethylene cracking would have to rise to 48 MM MTA to meet all consumption. That is clearly unrealistic; perhaps a more apt parallel is the United States, which has the world's largest capacity olefins sector, at 28 MM MTA of operating ethylene cracking. Yet the American market has only 300 million people. China has a population four times larger. Clearly Chinese ethylene cracking has considerable room for further expansion, but refining remains less certain.

China Looks Inward on Energy, India Looks Outward

Therefore, it is clear that two very different roles will emerge by mid-decade for China and India. China's importance as the largest oil market, the oil demand growth leader, the largest refiner, and the largest petrochemical producer in Asia Pacific will not change. Beijing's refining and base petrochemical capacity overall will expand still further, despite closures to increase energy efficiency. Yet these are all inward-looking trends, focusing on the need to support continued economic expansion. While focused on the domestic market, these trends will impact both China's ability and desire to import oil products and petrochemical goods. Chinese demand for selected oil product imports—such as Jet A-1—as well as its purchases of petrochemicals have made it a top target for regional export sales.

India's impact will be very much the opposite. While supporting domestic economic growth both in the short and long term, Indian refining and petrochemical additions are aimed at exports, not at solely meeting domestic market needs. While Beijing has captured most Western energy analysts' imagination far more than Delhi, it is India that will impact oil trade and product balances far more immediately than China.

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Easing Oil Demand Pressure: Coal-to-liquids (CTL)/Gas-to-liquids (GTL) and Unconventional Gas

Chinese government planners realize that the sheer size of the China market and the likelihood of at least moderately strong oil demand growth through 2020 will sharply increase the country's dependence on imported crude and, in the longer term, will become a security of supply issue, as well as a basic economic issue for long-term growth. Policy has been to conserve energy overall, slow the rate of oil demand growth by moving gradually to world price levels, encourage energy efficiency, and seek synthetic alternatives for conventional refined oil products.

While the main emphasis in China has remained on expanding overall refining capacity, shutting down small and inefficient old plants, and upgrading selected operating refineries, other supply options have also been pursued. Chinese planners have taken a multifaceted approach to trying to supplement oil products outturn from traditional refineries. Among the more important are:

The use of coal through various forms of CTL technology to produce oil products and petrochemicals.

The use of biofuels, including ethanol, methanol, and biodiesel, derived from a wide range of agricultural products. Chinese biofuels must be based on non-food feedstock. Chinese do not consider cassava a foodstuff and base most of their biofuels on this crop.

GTL technologies have been examined, though will unlikely be pursued at least in the short to medium term, as China suffers a shortage of domestic gas output.

Planners have looked at a number of different approaches to alternative energy. Yet the major thrust of replacing oil with synthetic alternatives will likely be by using coal, both for oil and petrochemical production. In the following section we will explore CTL technology and national plans to use coal in place of oil in China's future energy mix.

Current and Future Plans for Creating CTL Capacity

Coal can be converted into liquid fuel using several liquefaction processes under two general approaches, indirect and direct liquefaction. Indirect liquefaction is a multiple-step process that sees coal first gasified, then cleaned of impurities. If the more common Fischer-Tropsch (FT) method is used, the synthetic gas is converted through a catalyst into synthetic crude, then hydrocracked to create various products. If the Mobil patented method is used, syngas is transformed into methanol, also via a specialized catalyst, and methanol can be converted to gasoline by a dehydration sequence or, more likely in the case of China, used to make petrochemical products.

A complication little noted by most foreign analysts in CTL projects is that government regulation dictates that 20% of the raw material used must be processed in the province where it originated. This was intended to encourage spin-off economic development in the poorer, interior provinces that have lagged considerably behind coastal regions in economic growth. It also creates substantial economic inefficiency and, in the case of CTL, forces the siting of plants in coal-rich provinces that lack water, an absolute essential in coal cleaning and CTL processing. This explains, in part, why CTL plants were sited in the semi-desert of Inner Mongolia.

Chinese companies have also been exploring direct liquefaction of coal. This requires creating a chemical reaction at high temperatures and then using hydrogen gas and a catalyst to produce a liquid fuel. Direct liquefaction usually produces low-quality liquid fuel and, though currently used in a number of Chinese plants, will unlikely become a CTL path for future Chinese production.¹¹ In China, only state coal company Shenhua has pursued direct liquefaction and its future is very much in doubt; Synfuel China is the only domestic company developing homegrown technology based on the indirect FT process, and this will be the main approach for future CTL production. According to government estimates, coal made up 93% of China's remaining conventional reserves as of 2009, and despite the problems associated with CTL, China will cautiously push ahead.

Chinese companies began to build CTL plants for oil products as early as 2005, although initial NDRC approval was later rescinded over concerns about CTL's long-term emissions and water

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impacts. By 2009-2010, a number of small pilot plants of limited capacity were operating as precursors to much larger-scale commercial plants.

Initial estimates of future coal-based oil products were ridiculously optimistic. Shenhua, a large state coal company, planned three large-scale CTL complexes in Inner Mongolia (60,000 b/d, expanding to 100,000 b/d); Lu'an, in Shanxi (100,000 b/d); in Ningxia, in a joint venture with Shell (70,000 b/d); and a second project also in Ningxia (80,000 b/d), in a joint venture with Sasol, a leader in CTL plants worldwide. Independent CTL company Yitai also produces 16,000 b/d of CTL-based oil and petrochemical products at its Ordos, Inner Mongolia plant.

By 2010, only the Shenhua and Yitai Inner Mongolia plants produced synthetic oil product, the former at some 23,000 b/d—a fraction of its design capability—and construction for the Ningxia plant only began in late 2010, with costs escalating from an initial \$5 billion to \$7 billion. From 2006-2010, Shenhua invested 50 billion RMB (\$7.59 billion) in CTL plants, aiming for 10 MM MTA (roughly 200,000 b/d) production operating by 2015 and 30 MM MTA (300,000 b/d) by 2020.¹² These goals will only be met at a later date.

Over recent years the NDRC has become more cautious about coal-based synthetics, whether to produce oil through CTL or petrochemicals using coal-to-olefins (CTO) technology. Among the central planners concerns have been the huge project capital costs, substantial calls on limited water in arid regions and, most of all, the still-unproven efficiency of these technologies when production moves to a commercial scale

In the first year of full commercial operation of the Shenhua direct CTL plant (85% utilization rate), the complex produced somewhat greater volume than expected and, oddly enough, most of the output consisted of naphtha, not gas oil/diesel. Shenhua claimed the products met national quality standards, with a coal conversion rate above 90%.

Yet it is time to get to the basic facts of life for CTL. Most companies studying the process believe that plants need a crude oil base price of \$50/BBL to break even—a certainty in 2011's

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price climate of \$100/BBL+ oil, but not a certainty for the long-term future. All CTL plants in north central China are distant from the main consuming areas.

The conversion factors used by Chinese CTL planners have often been suspect. If dry ash-free coal (DAF) is the feedstock for CTL, then a plant needed roughly 2.5 MT of coal to create 1 MT of oil product. Yet for field coal, the ratio is in the range of 3-4 MT of coal for 1 MT of oil product. To create 100,000 b/d of product (assuming 1 MT of oil product is equal to 7.4 BBLs), a plant would need 14.8-19.7 MM MTA of coal feedstock. But water is also needed for CTL processing. According to Synfuels China, indirect CTL averaged 14.45 MT of water used to produce 1 MT of oil product. This means that a 100,000 b/d CTL plant would need roughly 4.93 MM MTA of water. Now certainly some of that supply could come from recycling, but these plants, located in the arid interior, will need huge volumes of water piped from distant sources.

The other main area for coal conversion has been to use coal, directly or indirectly, as a base material to create intermediates that would provide base petrochemicals. This is broadly defined as CTO technology. As is the case of trying to create synthetic oil product, desires to slow the rise in oil imports and utilize a domestic resource to strengthen security of supply have been main drivers.

CTO is competitive, if oil stays above \$80/BBL, in the view of Chinese petrochemical companies. Water use has been the biggest worry, both for oil products and petrochemicals derived from coal. Most CTO projects use coal to create methanol as an intermediate, the building block to create olefins (mainly polypropylene and polyethylene, but including other products such as glycols). The first pilot plant output in China began in early 2011. The leading international methanol technologies are provided by UOP and Norsk Hydro; Chinese companies also have local patent technology based on the Lurgi process, with Wison Engineering a leading provider. Wison expects to start operation of its 375,000 MTA Nanjing plant by June 2013, using UOP technology. It should be noted that this same path of coal to methanol can also be used to manufacture gasoline directly to utilize methanol as a gasoline component, or to manufacture dimethyl ether (DME), a fuel that can be used together with LPG as a road diesel substitute.

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As is the case with CTL, the first steps into CTO have been tentative, with small-scale plants and little likelihood this decade of replacing conventional naphtha-based ethylene crackers. While bearing in mind the problems of cost, distance, and water, we expect that CTL and CTO could make at least a limited contribution in substituting for conventional oil production and oil-based petrochemicals. Chinese planners expect that they will have at least a dozen commercial plants online by the second half of the decade, with long-term higher oil prices underpinning the viability of CTO.

Yet the government has had some second thoughts on both CTL and GTL in recent years, with the latest set of CTL/CTO guidelines released in April 2011. Earlier regulations in mid-2010 “rationalized” the sector by limiting CTL/CTO production in consumption areas and pushing new projects to the major coal mining areas of northern and western China.

The more important provisions of the tightened synthetic coal sector include: only the NDRC, and not provincial or municipal authorities, can approve CTL/CTO projects; CTO plants must have a minimum capacity of 500,000 MTA (roughly 10,000 b/d) and CTL plants (including those producing MTBE) must have a minimum 1 MM MTA (roughly 20,000 b/d). Projects using coal for syngas and some other specialty chemicals also had minimum capacity standards mandated.¹³

Table 9. China Coal-Based Oil and Petrochemical Plants (in MM MTA)

China Coal-Based Oil and Petrochemical Products Plants (In MM MTA)					
Company	Site	Technology	Capacity	Startup	Products
China Datang Corp.	Mongolia	MTO	0.400	12/2010	Polypropylene
Shenhua Coal Chemicals	Batou, Mongolia	MTO	0.600	8/2010	Polypropylene + Polyethylene
Shenhua Coal Chemicals	Ningxia	MTO	0.500	10/2010	Polypropylene
Tongliao Gold Coal	Tongliao, Mongolia	MTP	0.150	12/2009	Polypropylene
Qinghua Group	Yining, Xinjiang	SG	0.137	3Q-2011	Glycol
Xinmen Mining	Yining, Xinjiang	SG	0.200	4Q-2012	Mixed
Yintai Group & Petrochemical Products	Ordos, Mongolia	CTL	0.160	3/2009	Mixed oil
Projects Proposed but Pending					
Celanese	unknown	CTE	0.400	2013	Ethanol only; Can expand to 1 MM MTA
China Power/total	unknown	MTO, Total Patent Technology	1.000	4Q-2015	Mixed Polypropylene, Polyethylene
Shenhua/Dow	Yunlin, Shaanxi	CTO	4.200	4Q-2014	1 MM MTA Olefins, 3.2 MM MTA Other Chemicals
Wison Chemical	Nanjing	MTO	0.375	6/2013	Polypropylene
Notes: (1) MTO = Methanol-to-Olefins; MTP = Methanol-to-Polypropylene; SGN = Synthetic Gas; CTL = Coal-to-Liquids; CTO = Coal-to-Olefins; CTE = Coal-to-Ethanol Source: ICIS Data Petrochemical Database					

The Future of GTL in China's Oil Product Supply

GTL came of age with Shell's commissioning of the large-scale Pearl GTL project in Qatar, which should reach full production levels of 140,000 b/d by the end of 2013. GTL can produce almost the full range of products from LPG to fuel oil (gasoline is a major exception as a blended product), and GTL-derived products are extremely high in quality. The 140,000 b/d in GTL output from the Pearl plant, together with an earlier 34,000 b/d Qatar GTL project, Oryx, will be blended to provide up to 500,000 b/d of high quality products, depending on what product operators choose to maximize. Feed gas for both plants comes from Qatar's giant, wet North Field gas reservoir. The stripping of LPG and condensate from gas production used in GTL will add a further 350,000-400,000 b/d in products output directly or indirectly from LPG and condensate produced.

GTL, however, requires some very specific conditions to be considered for a large-scale profitable project. China, for the most part, cannot fulfill these conditions. Among the more important considerations:

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- A large reserve of relatively clean gas, with a premium, if it contains substantial NGLs
- The willingness to sell that gas to the GTL operator at a price well below world levels
- A premium for high quality GTL-derived product output

While China has substantial gas reserves, planners already worry that supply from conventional gas sources will be unable to keep up with demand. Further, the cost of GTL still is enormous, and planners await developments that will lower capital costs for a large-scale project to more reasonable levels. Shell spent roughly \$18 billion to develop its Pearl project, upstream and downstream, and while the super-major claimed it would have project payback in five to six years, many analysts remain skeptical.

Beijing's focus in attempting to have gas substitute for oil has been more on using methane as a substitute for transport fuels without conversion through a GTL process, and this has been concentrated on compressed natural gas (CNG), as well as small LNG plants to provide gas in liquefied form for transport and to provide gas to potential consumers beyond the national pipeline network.

CNG is an old idea that simply compresses gas for use as a fuel for specially modified automobile engines. It has the advantages of providing an easy substitute fuel for either gasoline or diesel; it burns cleanly and is best used in densely populated cities where relatively short distance travel is the norm. It is ideally suited for urban bus systems. CNG has been introduced in Beijing and across northern China, but has had minimal impact. In part this has been due to many other calls on gas supply, but we believe overall that China's lack of secondary and tertiary gas distribution, known as gas reticulation, in most major cities has made planners reluctant to promote this fuel alternative. Not only would thousands of CNG distribution points have to be built, all with gas storage, but entire urban reticulation systems would have to be built from scratch outside of existing infrastructure in Beijing and a handful of other major cities.

Australia pioneered the building of small LNG plants as a means of supplying gas to remote towns beyond pipeline distribution systems in the vast interior known as the Outback. The NDRC appeared to be backing this as a much more useful means of reducing oil product use

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through gas and LNG substitution for gasoline and road diesel. According to U.S. engineering firm Black & Veatch, 1.67 liters of LNG could replace 1 liter of diesel in vehicle use. In 2010, China had about 20 plants for small-scale LNG; the largest is Guanxi, Xinjiang, in China's Far West, which has a capacity of 0.4 MM MTA, or about 53 MM CFD, and is based on Tuha gas. Hong Kong-based Yunlin wants to build very small units of 0.040 MM MTA and 0.020 MM MTA in Qinghai and Tibet by 2011, with a focus on supplying landlocked interior markets.

China is also exploring the use of LNG as ships bunker. HK Towngas wants to sell LNG to small ships currently using marine diesel for 1,000-3,000 deadweight ton (DWT) vessels, and the Chinese and Hong Kong governments are reviewing this for use in riverboat traffic. While forecasts are difficult to pin down now, perhaps as much as 6 MM MTA of LNG may be used for ships fuel by 2020, replacing up to 60,000 b/d of bunker diesel and gas oil.¹⁴

Yet what ultimately limits the use of conventional gas as an alternative to oil use is the simple lack of immediately available gas supply. Until relatively recently, Chinese explorers looked only for oil; if gas was found, particularly in dry regions, a water discovery would have been more welcome. While proven reserves have risen—in the decade through 2009, proven reserves rose from 48.4 trillion cubic feet (TCF) to 86.7 TCF—consumption has been ballooning, in part due to the massive investment made in gas pipelines and other transport infrastructure. In 2008-2010, when gas demand declined in most consuming markets, China's consumption pushed full speed ahead, rising 17% in 2008 and 8.7% in 2009.¹⁵

We believe, however, that many forecasters have overstated future gas demand in this market. A primary and very major problem is the difference between the price of piped gas imports and the maximum allowable price for CNPC gas sales. In 2010, CNPC incurred a loss of 5 billion yuan (\$769.23 million) from selling imported gas via the second west-to-east pipeline at the same price as domestically produced gas. This has led to massive losses for CNPC, losses that will only grow as imports rise. It is estimated that piped gas sales in a southern city such as Guangzhou (Canton) should be at least 3 yuan per cubic meter for the gas seller to make a profit.¹⁶ While it was widely anticipated that the government would raise gas prices by the third quarter of 2011, inflation fears have delayed this.

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Typical was a forecast by Bernstein Research¹⁷ in June 2011. While we agree with this respected analyst that four factors will underpin sustained demand growth well into the next decade—industrialization, environmental concerns, transport and, most of all, continued urbanization—we believe that the essential issue of price has not been fully recognized. CNPC will not be able to subsidize piped gas imports forever; the central government cannot delay a top-to-bottom reform of the gas sector for years to come and while the building of gas infrastructure since 2000 has been impressive, much more must be done to complete a national gas transport network. Bernstein predicted China could overtake Russian gas demand by 2020; this is entirely possible. But as in the outlook of another respected energy analyst on gas (Wood McKenzie's forecast for shale gas output), we believe the difficulties and delays inherent in such huge sector undertakings have been underestimated and the issue of price and gas balances underplayed. A commonplace belief of most gas planners, upstream and downstream, is that completing usually takes longer and costs more than initially estimated.

China is bridging the gap between available gas supply from domestic output and potential demand through LNG gas imports as well. LNG originally was seen as a stopgap measure to supply gas to the Southern Seaboard, rather than extend the national pipeline system to cover all heavily populated areas of the national market. Yet it has become an indisputable support by 2010 in national gas supply. Similarly piped gas from Kazakhstan and Turkmenistan, and eventually Russia, was to be a supplement to domestic gas production, but piped imports have risen rapidly in volume from 2010-2011, and the difference in price between imported piped gas, roughly \$11-12/MM BTU delivered, and wholesale sales prices, roughly \$7-8/MM BTU, is hemorrhaging earnings at CNPC/Petrochina, which is responsible for these purchases. Longer term, the government has to close the gap between the price of gas imports and the price of domestic gas sale; since markets set international gas prices, this means either subsidizing imports, particularly of piped gas, or reforming the gas pricing system.

The Future of Unconventional Gas in Shale, Coalbed Methane (CBM), and Gas Hydrates

Unconventional gas production focuses on three main areas of development: shale gas, which uses fracturing methods to free gas enclosed by shale formations; CBM, which extracts gas often found in coal seams underground and uses this methane by-product like any other conventional

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gas; and finally gas hydrates, which are a crystalline solid composed of gas molecules, mainly methane, contained in a “cage” of water molecules. With current gas demand averaging about 13 BN CFD, far outstripping potential conventional gas supply, planners see unconventional gas development as the means to meet future consumption needs.

We can see some contribution, possibly significant, of shale gas and CBM to Chinese gas output by 2020, but gas hydrates, which in China are found only in marine sediments, (usually at a depth of 300 meters [M] or more), are only a long-term development possibility. While unconventional gas will be covered in other papers in this series, we have some brief observations on each type of potential gas supply.

Shale Gas

Government planners hope to have first commercial shale gas production by 2016, but CNPC only drilled its first horizontal gas well in 2010 and the first auctioning of shale gas acreage was only completed at the end of 2010, with only Chinese companies allowed to bid. China plans to increase its output to 15 BN CM by 2020 (1.452.9 BN CFD)—a fairly ambitious goal. Shale gas output will receive subsidies of \$0.04.9/CM or \$1.36.2/million BTU or the equivalent of what CBM producers were getting.

The Tarim (Turfan), Ordos (Inner Mongolia), Sichuan, and Bohai basins are deemed most prospective, though the Junggar, North China, and Songliao basins will be reviewed for future exploration. The Ordos and Turfan basins appeared to be the focus of initial Chinese efforts and are believed to hold only dry shale gas reserves. According to the U.S. Energy Information Agency (EIA), China possessed about 920 TCF in potential shale gas reserves, but this is only the loosest of estimates. Critics have noted that EIA estimates assumed that all potential shale gas reserves would be commercially viable, which is certainly not the case. Even CNPC, normally over-optimistic in reserves forecast, estimated that known shale gas resources were lower than EIA levels—with the Chinese company assessing reserves in the range of 741 TCF; the central government wants to have at least 35.3 TCF proved up by 2020, though it is unlikely that shale gas would add much more than 3%-5% to total Chinese gas supply by the end of the decade. Yet consultants such as Wood McKenzie foresee shale gas making a major

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contribution—perhaps as much as one-quarter of total gas output—by 2030.¹⁸ This may be optimistic, in view of uncertain geology and the painfully slow government award of shale gas blocks. By July 2011, only two tracts in Sichuan were won by bidders and the winners, Sinopec and a provincial CBM company, lacked any experience in shale gas.

Shale gas reservoirs in China are little understood and exploration of reservoirs minimal. The first challenge is trying to understand the complex geology, in order to make a more accurate commercial appraisal of its potential. Major problems must be overcome: a lack of gas transport infrastructure, in particular gas pipelines to transport output, in most areas outside of the Sichuan basin; high-cost drilling economics—the initial drilling for shale gas in China has been at great depths, averaging 3,400 M in Sichuan—and this is costly and must deal with problems of high-pressure and high-temperature gas reservoirs.

Shell has already pledged a \$5 billion investment to explore the Jingqui and Fushun-Yangchuan shale blocks with CNPC. BP likely will sign up with Sinopec by end-2011 to explore and possibly develop shale gas blocks in southern China. Yet other than Chevron, American interest has been relatively muted.

A big shift though may soon occur as Chinese government planners realize that shale gas often can produce large volumes of oil and NGLs in parallel, as has been the case in the United States in the Bakken and Eagle Ford developments. Generally, Chinese shale gas reserves were believed to be dry, but only more detailed surveys can confirm this. Gaining operating experience in shale gas development was a driver prompting Chinese investment in Canadian and U.S. shale gas assets in 2010-2011.

CBM

At end-2009, the NDRC projected gas demand would rise to 19.3 BN CFD by 2015, to 24.18 by 2020, and to 38.7 BN CFD by 2030. The commission predicted that gas production would reach 13.5 BN CFD by 2015, 14.5 BN CFD by 2020, and 24.2 BN CFD by 2030. In order to meet these ambitious gas production goals, the government undertook a dual approach initiative to jumpstart shale gas production and revitalize CBM output, which had languished for much of the

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past decade. A number of foreign companies, notably Texaco (now a part of Chevron), Shell, and BHP (now BHP Billiton) attempted to get CBM projects up and running in China over the past 15 years, with limited success. By 2010, only China United Coal Bed Methane Co. was allowed to develop CBM projects. CBM output in 2008 was 560 MM CFD and was projected to rise to 967 MM CFD at the end of the 2005-2010 Five-Year Plan.

In an attempt to revitalize the sector, Beijing approved three more state companies to work with foreign companies on CBM projects: CNPC, Sinopec, and Henan Provincial Coal Seam Gas Development & Utilization Co. It is curious that China has lagged in such a basic area of gas development. CBM represents a positive hazard to coal miners and it is likely that coal will continue to account for two-thirds or more of China's base energy supplies through 2020. Yet efforts have lagged badly and though consultants such as Wood McKenzie have claimed that CBM, coal-based synthetic gas, and shale gas could top 11 BN CFD output by end-decade, it would appear that CBM production will have to rise sharply by 2015 to meet those forecast volumes.¹⁹

What is the Future of Shale Oil in China?

Unconventional oil production will be covered in other papers in this series. Yet we would like to underscore certain themes for this sector.

We believe that future prospects for oil shale—where rock is crushed and retorted for its black oil content—are nil. Yet shale oil, where crude is extracted from between layers of shale, is a different story. As has been the case in shale gas, Chinese companies have only recently begun to recognize the possibilities of modern development techniques for shale oil. The industry had crushed shale for oil extraction since the 1920s, but since the 2010 cancellation of a Shell joint venture with Jilin Guangzheng Mineral Development Co., this development approach has been abandoned. Exploiting oil that is trapped between layers of shale is a somewhat different story. We expect oil to be produced from shale mainly as a by-product of shale gas development; volumes will remain relatively limited through 2020. Chinese geologists have yet to identify, let alone delineate, shale gas reserves that also contain commercial black oil.

IV. The U.S. Oil Industry and China: Competition and Cooperation Capabilities

Overview

The American oil, gas, and petrochemical sectors have had a bittersweet relationship so far with China, moving from the overwhelming infatuation of a generation ago—when U.S. companies upstream were willing to attempt exploration in every nook and crevice opened offshore to explore for oil and gas—to the frenzied hunt in the early 1990s to find any downstream project in China, no matter how improbable, for a major investment in the world's biggest developing economy.

Too many companies took questionable tracts offshore and found little oil or gas; many U.S. firms pursued dubious refinery projects in order to have any of them come to fruition. By the mid-1990s, American firms began to have second thoughts on both downstream and upstream investments. The recession of 1997-1998, though brief, was sharp and temporarily put American ambitions to rest.

Yet China remained and began a sustained period of growth from 1998-2010 that has made it the largest oil consumer in Asia, the biggest refiner and petrochemical producer in the region, and the long-term leader of what will likely be the world's fastest growing region of the world for decades. John Rockefeller's dream when he headed Standard Oil was to sell a gallon of kerosene to every Chinese household—to all 400 million inhabitants of the world's most populous country. American companies have returned to pursuing their ambitions in China simply because, as one executive put it, "To be a serious player in this century, you have to have an established position in the world's fastest growing market—China." They are pursuing that dream—not with the recklessness of first love, but with the more cautious eye of experience.

What has changed since the breakup of Standard Oil a century ago is that there are now three times more Chinese than in 1910; moreover, they have purchasing power, both personal and household, exponentially greater than China a century ago.. They are willing to engage the outside world now, as much as they will allow the outside world into China.

Three Rules of Chinese Energy Investment

Yet China, since its opening to outside investment as part of its shift from a centralized planned economy to a market economy, still has some basic rules, and companies that forget to keep these in mind will, in Rudyard Kipling's words, "share the fate of any fool who tried to hustle the East."²⁰

It should be remembered that China, despite its enormous progress in moving into the modern commercial world, is a place where standard international business practices are often ignored and corporate governance is minimal. And because companies are often either state-owned or have strong ties with powerful figures in government, it never is quite "business as normal" as it would be in Houston or New York; instead, it is less predictable and often ambiguous, such as business in Moscow, Dubai, or Lagos.

The three rules of Chinese investment are:

1. All investment, whether in oil, gas, petrochemicals, or power, is for the long haul. There is no instant Asia, and certainly no instant Asian profits.
2. China—and Chinese companies—will not allow foreigners to do for them what they can do for themselves.
3. A Chinese partner must be convinced, and remain convinced, that profits are being shared equitably or they will undertake every means, legal or semi-legal, to claw back what they consider ill-gained profits by their foreign partner. Written contracts only have full force when a Chinese partner is fully convinced of its equity to all investors.

Demand Apparent and Real: American Companies and Their Views on Current and Future Chinese Oil/Gas Demand Outlook

Companies experienced in Chinese markets, particularly integrated majors such as ExxonMobil and Chevron (which absorbed its former marketing company Caltex a decade ago), long ago realized the consistent overstatement of demand growth. Yet the long-term prize is entry into

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what will certainly be one of the largest, if not the largest, oil and gas markets of the 21st century and a major producer—and consumer—of petrochemical products. In agreeing to abide by international trade rules, China must eventually open up its domestic market to foreign companies for both wholesale and retail sales. While governments and companies will continue to try to place as many non-tariff, regulatory barriers to that entry, they are delaying, rather than preventing, foreign companies from competing in China's future energy demand growth.

However overestimated, there has been sustained demand growth and in order to be considered top players by mid-century, U.S. companies need to establish a position in this market, upstream, downstream, or in gas rather than oil, and with a long-term view.

A major difference between the investment frenzy of the early 1990s and now is that Chinese technology has to some extent narrowed the gap with American firms, notably in refining. Sinopec direct catalytic cracking (DCC) design for residual catalytic crackers (RCCs) is under consideration for use in petrochemical plants, oddly paralleling what Exxon Chemical did in its Singapore petrochemical operations. U.S. executives believe that technical/commercial skills rather than technology transfer will be the key focus of Sino-American cooperation in the future, in particular the introduction of more efficient methods of crude/product inventory control and in products blending.

Yet in some areas of the upstream—deepwater exploration, exploiting shale gas, developing high pressure, sour gas fields, undersea connections for oil and gas pipelines—Chinese companies can benefit from Western—and in particular, American—expertise.

U.S. oil and gas companies do have a number of concerns in investing in China. Among the more important are: a lack of intellectual property protection; the inability of government and state companies to conform to international business norms; unclear (sometimes purposefully vague) regulatory guidelines; foot-dragging in implementing measures promised to the World Trade Organization to open markets; the fact that some markets remain completely closed; active and open discrimination against foreign companies; and state secrecy as a shroud for a wide range of government activities.

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Further, few financial incentives are offered to foreign companies, and little in the way of tax breaks, for long-term investment. Upstream, Chinese landholders are reluctant to cooperate with explorers, as only the state holds mineral rights, and downstream price controls make it particularly hard for non-conventional oil and gas projects to break even. Unlike some Asian markets, there is no third-party access to either gas or oil pipelines.

Yet because of the long-term prospects of the Chinese markets, many companies are willing to persist in their investment plans. Beijing to some extent understands these problems, such as the slowness in getting project approval. The NDRC in 2010 promised it would make further efforts to “understanding new technologies, developing regulatory frameworks and weighing the impact on the local population.”

A final caution: Many American companies feel they get embroiled in broader Sino-American policy disputes. One cited that CNPC purposefully invested with Encana to develop British Columbia shale gas because they were concerned that the U.S. government would intervene if they attempted to form a joint venture based on American reserves. While this deal was, in the end, cancelled by CNPC, the concern that the U.S. government would intervene in Chinese investment in the American market remains. Government intervention to stop CNOOC's buyout of Unocal in 2005 has left a bitter taste for Chinese oil executives. Chevron, which was believed to have invoked government intervention, has moved carefully in China ever since.

What is clear about all U.S. companies hoping to share in China's future bounty is that the experiences of the 1990s have made them more realistic in their expectations and more determined to proceed slowly but surely to establish a long-term presence in this market. In the next section we will highlight three companies and how the lessons of the 1990s investment frenzy have shaped their current market strategy.

The Process: How U.S. Companies in These Three Energy Sectors are Positioning Themselves in China

In this section we summarize the overall view of U.S. companies and then focus on a specific company's strategy in each major energy sector.

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Upstream

Overview

Apache, Amoco, Arco, Burlington Resources, Chevron, ConocoPhillips, and Devon were among the companies most active in China's upstream in the past 20 years, drilling and developing oil and gas finds in the South China Sea and in the northeast China Bay of Bohai. Many have sold their interests or have had Chinese companies exercise their right to acquire their upstream assets. ConocoPhillips and Chevron, however, remain major foreign producers, particularly in producing the difficult, viscous, often high-acid crude found in the Bay of Bohai.

The latest field developments by American companies upstream have tended to focus on gas, with companies concentrating on developing difficult tight sands and sour gas finds in China's central Sichuan province. While Chevron will begin to produce sizable commercial gas volumes by 2012, ConocoPhillips's program has lagged completion.

New American upstream interest in China has focused not only on difficult conventional gas, but now also on shale gas, with Hess one of the pioneers in partnering with a Chinese firm. We expect other U.S. firms, perhaps those led by independents, to follow as Chinese oil executives realize that shale gas can also yield substantial oil and NGL output.

As detailed in the next section, the larger U.S. upstream companies have preferred to work with Chinese counterparts not in exploring China, but in third country markets where exploration prospects are greater and Chinese partners can contribute more.

Chevron Strategy

Chevron has been focusing on its Chuangdongbei project, the first large-volume sour gas development in China. While the super-major's first commercial output has been delayed by complex geography until early 2012, Chevron has found recoverable and proven gas reserves of 6.2 TCF, which will yield about 4.0 TCF of marketable gas. Initial output is planned at 740 MM CFD from two large-scale cleaning plants but will only be achieved late in 2012. A second phase would double output by 2016, but timing and volume will be dependent upon the operating experience gained in initial sustained production. The U.S. firm has considerable experience in

handling gas with large volumes of inerts as well as hydrogen sulfide, a gas that is both corrosive and explosive. Chevron hopes to be the partner of choice for developing technically challenging gas finds.

Downstream

Overview

In the early 1990s the full range of U.S. companies pursued refining, wholesale product distribution, and LPG terminals. Among the most active companies looking at downstream investment were Arco, Coastal, Conoco, Amoco, Exxon, Mobil, Tesoro, and Valero. Despite all of the efforts of all of these companies—as well as a host of European competitors—few actually were able to complete a large-scale downstream investment. Few projects moved to completion; in fact, until recently the minority Total share in the Dalian refinery and BP's share in Sinopec's Shanghai refinery (since sold off) were the only refining investments achieved before ExxonMobil's refinery started up in 2009.

While Chevron and ExxonMobil still hold considerable storage capacity in Hong Kong and Chevron operates a number of major LPG import facilities, ExxonMobil has become the only U.S. company with a direct ownership share of an operating refinery.

ExxonMobil Strategy

ExxonMobil, the largest U.S. major, is by far the best-positioned American company in Chinese downstream. The super-major has the greatest investment of U.S. companies in the Chinese downstream sector through the massive Fujian refinery and side-by-side olefins complex. ExxonMobil was insistent upon gaining direct marketing rights from its Chinese partners, including Sinopec, and seems well on the way, with Saudi partner Aramco, in building a vertically integrated oil/petrochemical company in Southeast China. ExxonMobil, unlike Total in an earlier investment in Northeast China's Dalian refinery, has been able to penetrate Chinese wholesale and retail trade and gain a foothold in the very profitable Chinese petrochemical sector. It should be noted that ExxonMobil used not only its considerable size and commercial capabilities, but also Aramco's promise of future crude supply to force an opening into Chinese oil product distribution.

Petrochemicals

Overview

International petrochemical companies realize that the emergence of a middle class, low per capita petrochemical consumption and rising disposable income mean the China market will continue to expand for many years to come. Further, there has been general consensus that in order to remain a competitive first-class petrochemical firm, a company must have an established position in the leading demand market as well as investments in areas where there is a substantial feedstock pricing advantage, most notably the Mideast Gulf. It is notable that many of the companies that invested in Chinese petrochemicals—Dow, Exxon Chemical, Shell Chemical, BP Chemical, and BASF—also have massive investments in the Mideast Gulf. It should also be underlined that Mideast petrochemical companies, such as Sabic, have felt the need to invest in Chinese capacity as well as at home. Both groups are playing a double-edged bet: investment in the region that has discounted petrochemical feedstock and investment in the market that is likely to grow for decades.

Dow Strategy

Dow attempted to parallel Exxon Chemical's entry into the Chinese market with a joint-venture proposal for Tianjin, which ultimately failed. Yet the company entered the sector through the back door by building one of the first plants using coal to create a wide range of base petrochemicals (as discussed in the CTO section above). Dow has not given up on building a conventional oil/gas-based ethylene cracker and hopes to have a plant operating by late in the decade. In the meantime, Dow has been focusing on building up its marketing, sales, and distribution network while moving toward full CTO output.

The New Competitors: How American Firms Weigh the Competitive Advantage of Chinese State Companies in Oil and Gas, Upstream and Downstream

American companies have been weighing the competitive advantage of their Chinese competitors carefully. Initially, the reaction of most firms was that China represented a threat to their oil—a sort of commercial paranoia tinged with the nationalist overtones seen in CNOOC's attempted buyout of Unocal.

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At that time, the initial CNOOC offer was more attractive to many Unocal shareholders than the initial Chevron offer concurrently on the table. Among the reasons marshaled to block the deal in the United States were that the state-owned Chinese company was competing unfairly with government money for a private company; that Unocal was an American company (though all operations had been transferred offshore to Asia Pacific, other than a small California-based corporate headquarters); that this represented strategic American assets; finally, that they had an ill-defined feeling that CNOOC was taking “our oil” though Unocal mainly had gas assets, at least in Asia Pacific, and most Unocal output, gas and oil, went to non-American markets.

U.S. firms have since developed more sophisticated thinking on working with their Chinese counterparts and in particular have been reconsidering how to do business with the top three companies: CNPC, Sinopec, and CNOOC. In part this reconsideration has come about because of growing Chinese ties with European firms. Shell and CNPC in early 2011 completed a \$3.2 billion buyout of Australian independent Arrow's assets in a CBM-based LNG project in Australia. The Anglo-Dutch major has worked with CNPC previously in upstream projects in Qatar and Syria. BP also has been an active upstream partner with CNPC, most notably on the development of the Rumaila and Halfaya fields in Iraq. Total has partnered with CNOOC in Nigeria and Uganda and appears poised to take up other frontier area developments with the Chinese offshore firm. Norwegian Statoil, like Italy's ENI, have signed vague strategic cooperation accords with Chinese companies, but surprisingly, Statoil has committed itself to a 40% farm-out to Sinochem, a Beijing state firm that once dominated Chinese oil trade, but now is considered well behind its state competitors CNPC, Sinopec, and CNOOC.

Generally U.S. companies prefer to focus on the three largest Chinese companies rather than smaller state-owned or private Chinese firms. Joint ventures upstream have dominated downstream, as most American firms, after the investment frenzy of the early 1990s, remained interested in a downstream foothold in the China market, but not through refinery investment. Finally, because of limited exploration opportunities in the opening of China to foreign explorers, most U.S. firms have considered partnering with Chinese companies in third-party countries.

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Overall the cooperation has tended to focus on the Big Three: CNPC, Sinopec, and CNOOC; cooperation has been slanted toward exploration more than downstream investment. Because upstream has dominated joint ventures with Chinese companies, joint investments have tended to be outside of China in third-party countries. Generally, these joint ventures, unlike some of the European initiatives, have been project specific rather than broad alliances, which may be overly restrictive for big players.

Aramco stands head and shoulders above competing Mideast Gulf State companies in China investments. The company has multiple investments in China, with the flagship Fujian refinery/petrochemical complex to be followed by a 200,000 b/d grassroots refinery with CNPC in Yunnan province, announced in early 2011. A proposed joint-venture refinery with Sinopec in Qingdao, however, was cancelled. CNPC has invested in a joint-venture grassroots refinery at Yanbu in Saudi Arabia, and Sinopec has been exploring for gas in Block "B" in Saudi Arabia. Sabic has commissioned a 1.0 MM MTA ethylene cracker with Sinopec in Tianjin and will further expand its petrochemical investment.

In contrast, other Mideast Gulf companies have signed many agreements but have yet to show any concrete progress on a wide range of projects. Qatar Petroleum signed with CNPC in 2008 to build a 450,000 b/d refinery, including a 200,000 b/d condensate splitter, but has been unable to move forward on this downstream project. After considerable delay, KPC has finally been approved for a 300,000 b/d joint-venture refinery with Sinopec at Zhanjiang located, like Fujian, in China's booming Southern Seaboard; like the QP plant, though, this is unlikely to start up until 2016 or beyond. Abu Dhabi, Iran, and Oman have made vague proposals to build downstream plants, but have not made any firm commitments.

An essential difference between Western and Mideast Gulf companies emerged early in the investment competition. Western companies, whether American or European, have generally been frustrated in their attempts to penetrate the Chinese domestic market, with the exceptions of ExxonMobil and Dow. They realize that in order to be major players in the 21st century, they must establish a presence in the domestic Chinese market, but they are not sure exactly how to proceed. In contrast, Mideast Gulf state companies want to fortify their stake in China as an

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outlet for future oil exports; fend off growing competition from piped oil sales, whether from Kazakhstan or Russia; and also gain some stake in future Chinese domestic oil demand growth.

CNPC, Sinopec, and CNOOC are each regarded quite differently by U.S. firms. CNPC, originating as the rump of the old Oil Ministry, tends to be seen as competent in basic drilling, seismic, and boilerplate exploration. While seen as very conventional in its exploration outlook, the company is highly regarded for inexpensive and thorough basic fieldwork onshore. CNPC has made substantial inroads in renting out its onshore rigs and drilling teams for basic exploration and development work, and it is known as a steady, dependable drilling company. Its low labor costs and dependable, if relatively simple, drilling equipment make it a desirable partner to cut exploration and development costs.

Sinopec, originally a petrochemical and refining company, has limited upstream operating experience. It is Sinopec that normally approaches foreign companies, including U.S. firms, to farm into emerging exploration and development opportunities, as the company farmed into Chevron's Gehem development in offshore Kalimantan, Indonesia. While Sinopec has some interesting and innovative patent technology such as its DCC process—a specialized form of residual catalytic cracking—American firms so far have shown little interest in working together in downstream projects with Sinopec.

CNOOC has long been regarded as the most professional of the large Chinese state companies and has the longest experience in working with foreign partners in its offshore China exploration and development projects. Yet in its foreign exploration, CNOOC has tended to either go it alone in acquiring frontier blocks or to turn to European companies, notably the United Kingdom's British Gas (BG), for farm-in opportunities.

All three companies offer substantial cash, such as when U.S. firms were under financial pressure during the recession of 2008-2010, as well as access to Chinese state funding; relatively inexpensive labor, often as experienced as their U.S. counterparts; and the entry into politically sensitive exploration areas, where a Third World state company would cause less controversy than a U.S. exploration firm.

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Just how much cash would China be willing to invest? From mid-2007 through mid-2010, China made over \$44 billion in loan and capital expenditure commitments to Venezuela. This included \$32 billion to be repaid in oil shipments, of which the \$7 billion granted in 2007-2008 already are exhausted; the latest oil-backed loan of \$4 billion was completed in mid-2011. The Chinese have committed to about two dozen joint ventures (JV) with state-owned Petróleos de Venezuela (PDVSA) worth about \$100 billion. In this case, since the host country Venezuela wanted to get away from American energy company influence, the chief partners for China have been European companies, in particular Total and ENI.²¹

But overall there remain many areas of cooperation for U.S. and Chinese companies in oil and gas. We will detail this relationship further in the following section.

Areas of Cooperation

Chinese state companies are working with American firms, both in China and in third country markets, in oil and gas, upstream and downstream, and petrochemicals. Many companies have expressed interest in developing even closer ties, focusing initially on the upstream sector, and the range of reasoning is diverse. A specific point many executives underline is that their firms in the United States are more interested in project-specific joint ventures than broad-based, often ill-defined “strategic” agreements without specific goals.

Working together with Chinese state companies—in particular CNPC and Sinopec, which have large-scale downstream as well as upstream assets—has helped to build a better and broader working relationship with a given company. More broadly, it also helped build a better working relationship with the Chinese government and promoted longer-term ambitions in that country's market.

In addition, it helped to neutralize the threat from other foreign cash-rich, acquisitive companies, backed by seemingly limitless state funding, and utilized cheap Chinese cash.

It also allowed Western companies to use Chinese equipment and labor for simple, standard well drilling and development. Chinese manufacturing and labor and their efficient supply chains cost far less than Western suppliers.

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From the Chinese company's viewpoint, the goals are similarly diverse:

Technology transfer in specialized areas of oil and gas development was part of the reason for the entry of a number of Chinese firms into CBM-based LNG projects in Australia, notably Sinopec's buy-in to the ConocoPhillips APLNG project and CNPC's entry into Shell's CBM-based Arrow LNG project.

Gaining operational experience in difficult exploration zones and new upstream techniques was a major reason for CNOOC's Chesapeake's shale gas buy-in.

As part of operational experience, companies also seek some degree of learning new technology in upstream, in particular LNG. This has been one of the driving forces behind the purchase by Chinese companies of more conventional LNG projects, such as Chevron's Wheatstone development in Western Australia

Partnering with the United States, and in general more sophisticated Western companies, has gained the Chinese access to prime tracts in a number of new markets, notably Australia and Libya.

Finally, as part owners of an upstream asset with U.S. companies, the American linkage provides some security of supply, should resource access be denied later by the host country.

LNG, more than conventional oil development, has illustrated the multi-faceted nature of these partnerships. When U.S. economic sanctions were supplemented by United Nations and EU measures in 2008-2009, Chinese companies signed a number of contracts with the National Iranian Oil Company (NIOC) for the development of LNG projects, including upstream offshore gas development, as well as the construction of downstream liquefaction facilities. Yet since then, very little progress has been recorded on any specific Iranian project, exposing Chinese companies' technical shortcomings in LNG.

In contrast, Chinese companies have entered Australian LNG projects with the clear intention of learning from their participation. Sinopec's partnership with ConocoPhillips's APLNG was

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earlier foreshadowed by CNPC's partnership with Shell in buying out Australian independent Arrow for the Queensland Arrow LNG project. CNPC's Huanqi Contracting and Engineering Co. (HQCEC) has been working with Shell on developing the onshore CBM reserves in Australia, as well as independently trying to develop liquefaction technology for small trains of up to 0.5 MM MTA. It hopes to commission its first plant in China's Shaanxi province by 2012. This CNPC subsidiary in January 2011 signed with Australian Liquefied Natural Gas (ALNG) to collaborate on building mid-sized liquefaction trains, using ALNG's patented OSMR liquefaction technology.

Concurrently, Chinese ship builders have entered the specialized field of LNG tankers. Hudong Zhongyuan received China's first international order to build four LNG tankers for long-haul routes for Mitsui and ExxonMobil for Australia and PNG projects. Hudong is a subsidiary of shipping conglomerate China State Shipbuilding. The size of the vessels appears to be 170,000 CM.²² While Chinese investment in Iran received most of the press coverage, Chinese joint ventures in Australia appear to have made far more progress.

CNPC, CNOOC, and Sinopec want to gain similar experience in exploiting China's potential shale gas reserves. CNPC only drilled its first horizontal shale gas well in Sichuan early in 2011. It still must gain experience in U.S.-developed hydraulic fracturing technology to exploit these reserves. U.S. independent Newfield Exploration signed an agreement with CNPC to study Sichuan's shale gas reserves, but further technical cooperation is needed with other firms if China is to move ahead quickly on gas and shale oil development.²³

While foreign companies have been prohibited from bidding directly for the eight blocks that the Chinese government has opened for shale gas development, it is likely that American companies will play a major role in unlocking these reserves. Hess signed in February 2011 to jointly develop shale gas with Sinochem, a second-tier company. Beijing wants shale gas to account for 8%-12% of total gas output by 2020, a goal that is unlikely to be achieved without accelerated development efforts and the pairing of foreign companies with Chinese shale gas developers.

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CNPC had attempted to make the biggest Chinese investment in this sector, offering \$5.52 billion for a 50% stake of Encana's Cutbank Ridge assets. Cutbank Ridge in British Columbia had production of 510 MM CFD and proven reserves of about 1 TCF. Yet by July 2011, CNPC pulled out of talks on the joint venture, effectively cancelling the deal. Various explanations were offered: that the Chinese government overruled the company; that Encana would not allow CNPC operational participation in managing the project; that CNPC grossly overpaid for an untested asset; that the deal was dropped because CNPC hopes now to form a shale gas partnership with Shell in Canada. None of these suggestions convinces fully. Yet it is a likely sign that the Chinese state firm will shift to a more focused and commercially minded approach to future international asset buying. CNPC planned to produce 1.47 million barrels of oil equivalent, or half of its total output, from overseas projects by 2015.²⁴

Another area of potential interest is deep offshore oil and gas exploration and development. Upstream analysts believe that Chinese companies cannot build offshore platforms to operate at below 610 M or rigs below 9,000 M. CNPC has been searching for foreign partners to gain technical skills to allow for deepwater exploration. The company hopes to begin deepwater exploration by no later than 2015. China only completed its first deepwater semi-submersible drilling platform at end-2011. CNPC has begun designing its first such platform (capable of drilling to depths of 10,000 M) and hopes to launch a prototype by 2013 from its Liaoning shipyard.²⁵

CNOOC, the state company that until 2004 had a monopoly on offshore upstream projects, will invest some \$50 billion in deepwater oil and gas projects in the South China Sea. The Chinese firm's planners reportedly are worried about Canadian company Husky's capabilities for the country's first deepwater gas development, Liwan. This appears to be exactly the sort of opportunity that U.S. companies should consider.

We expect other opportunities for joint projects to emerge as Chinese companies seek better management techniques as much as more sophisticated technology. We see as particularly promising LNG project operatorship, oil product and stocks management, carbon sequestration, second-generation biofuels, and the introduction of better integration of oil refining and petrochemical plant operations. Of course, these are not American preserves—many European

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companies have equal, if not better capabilities—but would appear to be promising areas of cooperation to explore.

Table 10. China Oil and Gas Acquisitions by Company—Sinopec

China Oil & Gas Acquisitions by Company - Sinopec	
Date	Acquisition
12/2008	Bought Tanganyika Oil with Syrian assets
5/2009	Petrobras sells 200 MBD for \$10 BN loan for 10 years. CDC made the loan.
6/2009	Canadian Addax Upstream assets only
4/2009	10% Canadian Syncrude Northern Lights
9/2009	Purchases Canadian Independent Tanganyika Oil
11/2009	Sinopec signed to purchase LNG from PNG LNG & will purchase equity in the project
12/2009	Russian Independent Urals Energy
4/2010	Bought 9% stake in COP's Syncrude Canda JV, which would produce 375 MBD at cost of \$4.65 BN.
4/2010	Petrobras will sell farm-in for two blocks in Para-Maranhao basin
9/2010	Replaced Indian Mittal as Lukoil partner in four Kazakh fields as well as exploration tracts at estimated \$1 BN plus
12/2010	Bought 18% stake in Gendalo-Gehem project ex-Unocal and has 32 MBD condensate, 1.1 BN CF gas for Bontang
11/2010	Bought 40% JV stake in two grassroots refineries total 400 MBD at cost of \$4.8 BN share; total \$12 BN
1/2011	Bought Oxy Argentine assets, 393 MM BOE at \$2.45 BN
3/2011	Purchased 40% of Repsol's deep water assets in Brazil for \$7.1 BN
4/2011	Took 15% share in ConocoPhillips/origin APLNG project & 20-year purchase contract, with minimal \$5.66 BN investment

While CNPC led the expansion of Chinese companies abroad, Sinopec led the Big Three Chinese companies in overseas acquisitions in 2009-2010.

Table 11. China Oil and Gas Acquisitions by Company—CNPC/Petrochina

China Oil & Gas Acquisitions by Company - CNPC/Petrochina	
Date	Acquisition
1/2009	Gorgon LNG supply purchased and equity comes later from ExxonMobil sales
4/2009	JV with Kazmunaigaz to buy Kazakh upstream assets at \$5 BN.
5/2009	Singapore Petroleum Corp. 45% controlling interest at \$1BN in Singapore Refining (Downstream); plans full buyout of SPC
6/2009	PSC Working contract S. Pars
6/2009	PSC Rumaila Oilfield Iraq
7/2009	Awarded S. Pars LNG project after western companies' blow-out
7/2009	Equity Azadegan Oilfield Iran
7/2009	Sells 70 MBD and then 95 MBD to CNPC for two \$1 BN loan
8/2009	Takes 70% stake in Iran's Azadegan field
9/2009	To invest \$16 BN in Venezuelan syncrude projects
9/2009	Secures offshore PSC in Qatar
7/2009	JV to expand Costa Rica Refinery at cost \$1 BN
11/2009	Takes long-term storage in St. Eustatius tank farm; negotiating to buy Valero Aruba refinery
11/2009	Rumailia technical contract; 2nd after initial Al-Ahdab in 11/2008
2/2010	Venerex Canadian Libya assets
2/2010	Halifya technical contract Iraq with Total and Petronas, estimated 4.1 BN BBLs
6/2010	JV with Encana to develop British Columbia Shale Gas
11/2010	CNPC will expand Cuba's Cienfuegos refinery, with China ExIm credits and build LNG terminal
3/2010	Bid with Shell to buy Arrow CBM assets at \$3.2 BN
1/2011	Bought 50% of Ineos Group with access to half of 400 MBD of UK, France refineries at cost of \$1.02 BN
4/2011	Agrees to increase gas imports from Turkmenistan's South Yolotan gas field, raising purchases by to 60 BCM (5.8 BN CFD) by 2020. The China Development Bank awarded \$4.1 BN loan to state Turkmengaz, the third in less than two years, parallel to the gas contract.
5/2011	Buys 19.9% stake in Australia's Liquefied Natural Gas Co. at \$28 MN, allowing LNG engineering arm Huanqi right to use ALNG patented liquefaction technology; will finance Fisherman's Landing LNG project.
7/2011	Pulls out of a \$5.52 billion joint venture with Encana to develop shale gas in Canada.

CNPC, despite its original upstream orientation, has been far more active than Sinopec in acquiring overseas downstream assets and its principal holdings now are in northwest Europe and

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Singapore. In pioneering overseas upstream purchases, the company has had a rather scattershot approach. The company lags CNOOC in its upstream technology and operating experience; it lags Sinopec in downstream technology and operational skills in refining and petrochemicals.

Table 12. China Oil and Gas Acquisitions by Company—CNOOC

China Oil & Gas Acquisitions by Company - CNOOC	
Date	Acquisition
2/2009	Canadian Independent Kosmos Ghana Jubilee find
5/2009	Australia BG CBM 10% Project share; buys output
3/2010	CNOOC/Total – one-third each of Tullow Uganda
5/2010	CNOOC takes 63.74% share in Misan development to raise output to 450 MBD; third technical service accord to Chinese companies in 2009
2/2010	Buys share of UK independent Tullow's Uganda blocks
3/2010	Forms 50% JV company with Argentina's Bidas at cost of \$3.1 BN
2/2011	China offered \$14 BN in soft loans, as CNOOC and state Ghana offered \$4.5 BN for upstream assets of independent Kosmos, after government block sales to ExxonMobil. Includes country's Jubilee find, which started up 12/2009.
7/2011	CNOOC acquired bankrupt oil sands producer Opti Canada in a \$2.1 BN deal, acquiring 729 million barrels of reserves, on a proven and probable basis in four projects..

Table 13: China Oil and Gas Acquisitions by Company—Sinochem

China Oil & Gas Acquisitions by Company - Sinochem	
Date	Acquisition
8/2009	Purchased Emerald Energy assets in Syria and Columbia
5/2010	40% farm-in for Statoil's Peregrino offshore project for \$3.1 BN

V. Asia-Pacific Impact: Implications for Global Energy

Asia Pacific, Specifically China, Still the Long-term Growth Market for Oil, Gas, and Petrochemicals

While it is unrealistic to expect, as many Western analysts apparently do, that breakneck growth rates will continue forever, it is a fairly solid bet to assume at minimum that Asia Pacific will lead world demand growth in oil and likely in gas as well. It is also a fairly solid wager to

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believe that China will make up a good part of that incremental demand growth, if not an absolute majority of additional oil and gas demand, through 2020.

A common error among Western analysts looking at Asia Pacific has been to pay too little attention to price controls and oil product subsidies and their impact in creating unnaturally high energy demand growth. Though China's government has not been convinced fully of the wisdom of markets in quickly adjusting supply and demand, it is inevitable that China will move to free market pricing. The great unknown remains—when?

China has made up 50% or more of Asia Pacific's demand throughout the past decade (2000-2010); Asia Pacific has accounted for nearly half, and often accounted for a majority of global incremental oil demand in that same period.

Yet we believe that oil demand growth rates will slow in China as the economy matures and as prices are brought closer to world averages. As India realized in the 1990s, the economy cannot afford the drag of retail oil product subsidies forever, and subsidies and price controls eventually are a drag on economic growth. However, we expect neither a peak in Chinese oil demand, or in overall energy use, to occur before 2020, although it is likely that Chinese oil use will peak by 2025.

China's Impact on Prices, in Asia Pacific, and Across the Globe

China's impact on crude balances, regional supply/demand, and premiums/discounts for specific crude groupings is tangible, substantial, and will only grow more important through the decade. Even when Chinese oil demand peaks—let us assume between 2020 and 2025—China's crude imports will still likely grow as domestic oil output declines.

First and foremost, China's impact on crude prices is simply displacement. When China buys 5.5 million b/d in one month, that is a lot of Mideast oil going east, not west. Yet Beijing's appetite for crude imports has only accelerated the shift of Mideast Gulf crude exports to Asia Pacific rather than to the Atlantic Basin.

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Second, Chinese buyers have often focused on specific grades, or crude groups, subtly influencing their value. For years Chinese refineries were limited in the amount of heavy sour crude they could run as a proportion of their slate, thus enhancing a sizable premium for Oman, a Mideast sweet grade that has a high outturn of middle distillate and, in particular, superior quality diesel. Similarly, when Chinese refineries expanded capacity to process high-TAN or highly acidic crude grades, they shifted the dynamics of international marketing in these crudes.

Finally, China's growing crude imports have made all traders very aware of the pricing relationship between crudes marked off of Brent, including African and South American grades, and those priced off of Oman/Dubai or Dubai alone. When the difference between these two markers becomes large enough to cover added freight costs, Asian traders, not China alone, often come into the market as avid buyers.

The impact of China on product prices is harder to gauge, though certain trends appear likely. China will continue to export surpluses of lower quality product—normally gasoline, general kerosene grades, and general gas oil, as well as paraffinic naphtha—when stocks grow long. It will continue to import high quality Jet A-1, gasoline components, and occasional gas oil blendstock, but overall exports will be a function of the domestic market's balance, not an attempt to sell more abroad.

Yet when there is a short-term squeeze, the impact can be dramatic. At the end of 2010, general gas oil cargoes were not only arriving from traditional suppliers, such as South Korea, Singapore, and the Mideast Gulf, but were also from the Atlantic Basin. China's price impact is simply too big to ignore.

All Large International Companies Want a Piece of the Chinese Action, Yet China Will Do Whatever It Can for Itself Without Any Foreign Help

China will do whatever China can for itself and on its own terms. Yet if China is truly the premier market of the 21st century, all top oil and gas companies must establish a position in that market to remain in the premier league of energy. The increasing competition and cooperation of

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U.S. companies with Chinese firms in third-party markets is simply part of the longer-haul process of getting to know your potential friends and enemies.

In the Medium Term (3-5 years), Coal Use Can Only Be Capped; Longer Term, It Will Be Difficult to Shift Away from Coal

Those who believe that an economy that is more than two-thirds dependent on coal, has limited actual and potential oil resources, and is likely to continue to register strong economic growth for some time will somehow be transformed into a green paradigm by 2020, much less by 2015, have not done their sums properly.

During the Kyoto Treaty talks, let alone the Copenhagen follow-up, one judgment by many Western observers struck APEC analysts as particularly absurd. Many Western observers bemoaned what they considered China's lack of proper green credentials. Rather than recognize how far China has gone to clean up its act, literally and figuratively, they preferred to criticize Beijing for not acting as an Asia-Pacific clone of California.

Beijing has done a lot in a relatively short amount of time. It cannot—and will not—jettison economic growth in favor of fashionable green trends, carbon warming or not.

Yet as has been the case in Newly Industrializing Economies (NIEs) such as South Korea, Singapore, Taiwan, and Hong Kong, growing prosperity also increases an emerging middle class's desire to go beyond filthy air and dirty water. We believe that this desire for an overall cleaner environment, coupled with China's continued urbanization, and paralleled by government efforts to reduce energy intensity ultimately will cap and eventually decrease coal use—but this is a process of decades, not years.

China's Impact on Supply/Demand in Asia Pacific and Beyond

By its sheer size, and even if oil demand growth slows due to freeing of domestic product prices, abolition of retail subsidies, and the maturation of the Chinese economy, China's oil use is big and by 2020 will be substantially bigger. Often the influence of China on energy balances in the

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region is simply that of displacement—the sheer size of China's market share as a proportion of the East of Suez market demand is so large that it cannot help but affect other regional markets.

We see this influence more on crude than on products, and China's position as a magnet for incremental crude oil supply—from the Mideast Gulf, Russia, the Central Asian Republics, and the Atlantic Basin—cannot be underestimated. Asia began to increase its share of Mideast Gulf crude exports in the 1980s. The phenomenal growth of China's oil thirst has only accentuated the trend. We will see vast geopolitical shifts in oil flow by 2020, with China assuring at least a baseload of secure black oil supply from multiple oil pipelines—from Russia, Kazakhstan, and Myanmar.

If China's oil output peaks at roughly 4.4 million b/d, as seems likely late in the decade, all incremental oil demand will have to be met with imported crude. When one believes Chinese demand by 2020 will be 16 million b/d or 18 million b/d or 22 million b/d, it is clear that crude imports would total well over 10 million b/d. And the most likely places to supply most of it are the Mideast Gulf, Russia, and Central Asia.

China's role in product balances will be far more nuanced. Overall we have assumed that policy will remain little changed: products will be exported that are surplus to domestic market needs, and imports, when they cannot be met by Chinese refineries, will focus on a handful of specific items such as aviation fuel. Overall we anticipate regular exports of lower quality gasoline, general grades of kerosene, and low quality gas oil, as well as scattered sales of other products based on refiners' logistics. Imports will likely center on N+A naphtha grades for increasing gasoline production, specialty gasoline components, jet aviation fuel, and possibly road diesel blend stocks to boost transport fuel quality. Yet we believe strongly that China will try to meet as much of domestic product demand as possible, and that oil product exports will be a function of unwanted refinery outturn, often of poor quality.

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China By Far Represents the Largest Single Country Market in Asia Pacific, Yet Estimates of Chinese Oil Demand in 2009 are Still Less than Half that of the United States

Yet there has to be a perspective: big or small, fast or slow, tall or short are all relative terms. That China's oil market is by far the biggest in Asia and certainly will become far bigger still is indisputable. Yet two points must be emphasized: In 2010, Chinese oil demand of about 8.3 million b/d was still less than half that of the American market. Will Chinese demand growth continue at rates of 4.5%-5.0% through 2020? This is increasingly doubtful as prices move toward world levels, as the government begins to enforce energy efficiency as its primary criterion for oil use, and as Beijing's dependence on oil imports grows. It is the volume and the growth of those crude imports—rather than Chinese demand per se—that will shape international oil markets the most through 2020.

Will China Be a Product Exporter?

As discussed earlier, the buildup of Chinese refining and base petrochemical capacity will slow somewhat, but will continue at a steady pace, at least through mid-decade. But if demand growth slows due to high oil prices, or economic growth slows within China as the country fails to shift longer-term growth from exports to domestic consumption, a substantial supply overhang could emerge in China by 2020. Then-IEA executive director Nubuo Tanaka observed in early 2011 that not only tightened monetary policy, but also changing domestic gasoline prices in China, has had notable impact on decreasing demand growth. Also interesting was his linkage of demand destruction as occurring equally in both China and the United States. This appears to be the shape of things still to come.²⁶

We believe that any sustained attempt to export oil products would be scuppered from the start by China's inability to pump enough crude to supply its own refining needs. Certainly there will be regular exports, chiefly of lesser quality material, and it is likely, if the current pricing system continues, that there will be substantial overhangs of product that will have to be exported. But becoming a products exporter based on imported feedstock takes fast-moving, agile commercial refining based on market realities, and these are attributes generally not associated with Chinese refining.

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Chinese Demand Growth Underpins Asia Pacific but Will Demand Growth Patterns Mature More Quickly because of a Shift from an Export-led Model?

If Chinese oil product prices are firmly based on the economic value of that product, and if China is successful in shifting away from an export-led economic growth model to one based on domestic demand, we see it likely that demand growth rates will slow faster than most now realize. Further, we believe that many forecasts underestimate the new determination of the Chinese government to restrain oil demand growth. The NDRC would like to cap total national oil demand growth at 12-12.5 million b/d, perhaps before 2020. While we do expect that the peak of Chinese oil use may be post-2020 and the cap will be higher—perhaps as much as 14 million b/d—we have no doubt that oil demand will be capped in the foreseeable future. Future oil demand growth will be tied ever more closely to economic growth in the China market. But since energy efficiency will be a key aim in the current five-year plan, ending 2015, we do expect demand growth to slow overall. Energy efficiency, as we earlier highlighted, may well be the back door for the government to push toward market prices that reflect the true economic worth of an oil product.

Incremental Crude Needs will be Met by Long-haul Supply; China will be the Focus of a Battle between Piped Crude and Mideast Gulf Seaborne Supply

Pipelines, both crude oil and gas, will have multiple impacts on China's energy future and have begun already to reshape the relationship of Mideast Gulf exporters and Asia-Pacific importers, as well as crude pricing relationships worldwide.

China began promoting oil pipelines for a number of reasons, but most relevant were:

- Diversification of supply by increasing imports of Kazakh and then, Russian crude on all-land route pipelines
- Security of supply because pipelines, unlike tanker shipments, cannot be interdicted by a hostile navy
- To reduce import costs and avoid marine chokepoints, which were the primary supports for the Trans-Myanmar project

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- To broaden the range of crudes Chinese refiners used—an argument made for both Kazakh and Russian pipelines
- To speed development of an alternative source of crude supply by encouraging Russia to fast-track Russian Far East oil exploration and development. This push would allow the Russians to fast track development in sparsely populated regions by proving an instant oil export market.

Pipelines for China are as much a geopolitical as a commercial decision. Through the Russian, Kazakh, and Myanmar pipelines China will be able to import by 2015 a maximum 2.8 million b/d, or approximately one-sixth of total crude needs at that time.

Yet for the Mideast Gulf crude exporters, who considered Asia Pacific their sales backyard and assumed they would be able to—unchallenged—set future prices for crude imports, these pipelines represent a challenge. Not only will continental Eurasia emerge as a major source of Chinese crude supply, but the quality of crude they will sell, mid-weight to heavy and containing far less sulfur than most Mideast Gulf grades, will change pricing relationships between light and heavy crudes as well as sweet crudes low in sulfur, and sour grades high in sulfur.

For Western crude buyers, particularly in Europe, it will underline the shifting balance of power East of Suez, as Russian and Kazakh export sales shift to Asia Pacific.

Saudi Arabia and Qatar have Moved into Full Chinese JVs; Will Oil Producers Push Out the Majors in Future Chinese Partnerships?

Western oil companies, in particular the majors, have expressed growing concern that Mideast Gulf state companies, in particular Aramco and to a lesser extent QP, will become the preferred foreign partners for downstream projects in China. No doubt they have an asset and a need that Western companies do not possess: substantial volumes of crude oil to export and the need for secure sales outlets to absorb future crude production. Yet even if Kuwait—and possibly Venezuela—joins Saudi Arabia and Qatar in large-scale Chinese downstream projects, we believe that Western companies will have a place in the fast-changing Chinese domestic market.

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Tremendous and Continued Growth of Chinese Upstream Acquisitions is Resulting in a Large Volume of Crude Imports Coming as Equity Oil

As could be seen in our Chinese acquisitions list detailed earlier, China's spending spree continues—the recession spurred further purchases of (mainly) upstream assets abroad while China used its cash mountain to buy into any future potential oil or gas project that showed promise worldwide. Although Western companies complain of this, they used the same technique to open up Venezuela and Russia for oil and Saudi Arabia for gas in the earlier downturns of the 1990s. It should be noted that while commercial factors are the final determinant of whether a Chinese company buys an asset or not, like Japan there is a close government coordination of finance and natural resource acquisitions. If world oil output peaks at roughly 95 million b/d due to political/policy issues, rather than a geological limit, it will be interesting to see whether the Chinese model remains so robust.

Transport Fuels Most Difficult to Substitute; What China Will Do to Meet this Challenge Will Impact the World

It is a basic principle of market analysis that in interfuel competition, substitution of stationary oil use is generally easy to make. Gas, coal, hydropower, or nuclear were the traditional alternatives for power generation and now have been joined by wind, geothermal, and potentially tidal generation. In petrochemicals, naphtha use can easily be backed out by ethane, LPG, and condensate, among the traditional alternatives, with new coal-based and gas-based synthetic feedstocks soon to become fully commercial additional choices.

Yet substitution of transport fuels is a far more difficult task. It has been the experience in Asia as much as in the West that when average income reaches a per capita level of roughly \$6,000-7,000, vehicle ownership takes off. China has already moved from the bicycle to motor scooter to motorcycle stages, and while the new cars sold may be smaller and many of them powered by alternative fuels or as hybrids, there certainly will be millions more vehicles operating by 2020, most of them running on products derived from oil. While China had roughly 49 million cars on the road as of January 2010—compared to more than 250 million in the United States—and though more than two-thirds of new car sales are of smaller vehicles with engines of 1.6 liters or

less, that still means that transport fuel demand will be among the more difficult sectors to supply throughout this decade.

And what happens when China moves to the next stage of “Keeping up with the Zhangs” when the average Chinese family lives in a large city, runs the air-conditioning at peak on a hot late summer afternoon, and owns, as a matter of course, a washing machine, dryer, dishwasher, refrigerator, freezer, electric vacuum, and flat-screen television? What if the average middle class family takes it as a right to drive the family car away for vacation, or take a trip abroad by air—as their Japanese, Korean, and Taiwanese neighbors now do. The energy demand numbers will be breathtaking.

Supply Fears are the Constant Refrain to Chinese Energy Planning

As security of supply issues provided the background theme music to the story of Asia's march to prosperity—first in Japan, then in the NIEs, and now in developing Asia—the worry about obtaining access to a sufficient volume of future energy supply has become a consistent worry to Chinese planners. For China, dependence on imported oil is a new concern; this was also the case in Japan. Before the first Oil Shock no one assumed supplies could triple in price overnight or suddenly vanish.

For a growing giant such as China, it is not only a question of access to energy, or the price of future energy imports, but whether such imports would be hampered in times of confrontation with other countries, notably the United States. China's growing import dependence, and in particular its dependence on maritime trade, has planners very much worried about what options China could pursue if the U.S. Navy restricts energy imports. Hence the push for pipelines, the drive to better utilize domestic coal potential, and the support for solar- and wind-powered electric generation.

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China's Sheer Geographic Extent, Enormous Population, and Fast Economic Growth Make It Difficult to Fit into a World Energy Pattern, yet China Must Adjust to the World as Much as the World Adjusts to China

Looking at China and its particular, if not unique, characteristics—its sheer size in terms of both geography and population, its transition to a market economy, its awkward mixture of economic capitalism and political authoritarianism, its fast-track and sustained economic growth—the analyst is tempted to simply throw up his hands and say that China and the Chinese energy landscape are simply unique and have no parallel to any other market.

Yet a closer examination shows an enormous number of parallels with other developing markets and other Asian and Western markets. It would perhaps be more useful to add one further way of looking at China and its energy sector: China is a continental country in sheer geographic extent by definition, such as Australia. Alternatively, it is a country so large that its energy needs—in particular for transport fuels—make it a part of this grouping that includes markets such as the United States, Canada, Russia, India, and eventually the EU. The peculiar pressures on energy use imposed by vast expanses of territory make China in many ways analogous to these continental markets, though they vary significantly in their level of economic development.

A final consideration: While China has slowly, awkwardly, carefully been trying to define its place in the global energy community, the rest of the world just as cautiously has been trying to understand and accommodate China's future role for oil and gas. The period of mutual adjustment will likely continue for at least some decades.

VI. Conclusion

China's long period of sustained economic growth since the 1980s has made it the dominant oil and gas player in Asia and a leading market worldwide. While the size of Chinese energy needs is unsurprising to anyone who has followed this market over the past three decades, China's impact on global oil demand, trade, markets, and pricing only became apparent to many Western observers in the past decade.

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Chinese statistics have been of doubtful quality for some time. The unsophisticated use of Chinese data, combined with some inherent—and mistaken—economic assumptions lead to a wide range of misunderstandings about Chinese energy.

Price controls and retail subsidies have long kept the price of oil products in China below world levels and encouraged unnaturally high oil demand growth. With crude oil imports topping 5 million b/d, the Chinese government has finally begun to tackle the problem as an energy security issue and has begun to restrain oil use through implementing measures to improve energy efficiency.

China is the largest volume oil consumer East of Suez. China operates the largest volume of refining and petrochemical capacity in Asia Pacific and will continue expansion of its downstream throughout this decade.

The product group of gas oil, including road diesel, dominates the Chinese demand barrel; China's gas oil demand of nearly 3.0 million b/d is larger than total oil consumption by all markets East of Suez with the exceptions of Japan and India. Diesel made up a majority of land transport fuel, though it is uncertain to continue as the dominant road fuel.

In slightly over a decade, China's ballooning base petrochemical capacity has made it the major producer—as well as consumer—of base petrochemicals East of Suez. Its ethylene cracking capacity in 2011 was nearly equal to that of the Mideast Gulf's two largest volume exporters, Saudi Arabia and Qatar, combined.

To meet this runaway demand growth, China has increasingly imported crude oil and recently surpassed Japan as the largest volume regional oil importer—despite also producing the largest volume of crude in Asia Pacific. We expect crude imports to continue to grow, albeit at a slower pace.

China is turning to a number of alternative forms of energy to attempt to slow oil demand growth. Coal has long been the single largest source of Chinese energy supply. Planners hope it

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will make a significant contribution to providing synthetic oil and petrochemical products by end-decade.

China's long-term growth, its sheer size, and its future market prospects have American companies still determined to build a position in the Chinese market. Upstream investment hopes center around specialized areas of exploration and development, in particular difficult conventional gas reserves and shale gas; downstream interest has been more muted, but has focused on conventional refining and base petrochemical plants.

U.S. firms have learned from the investing frenzy of the early 1990s to pursue their China ambitions through a long-term strategy. Most believe that in order to remain recognized international oil and gas companies they have to establish a strong presence in the China market over the coming decade.

China has been accommodating itself to the global energy stage as much as the rest of the world has been adjusting to a new and major player in international oil and gas. The adjustment process has and will continue to work both ways. Chinese companies can play a constructive role in international oil and gas trade, markets, and investment as much as foreign companies can help to modernize and expand China's energy sector.

Notes

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