Crystallography: The Long-Term Price of Oil

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It seems only the proverbial blink of an eye since the principal determinants of the price of crude oil on world markets were the tax-paid cost of the Burgan field in Kuwait and the producing allocations decided by the Texas Railroad Commission. Crude oil was in such abundant supply 50 years ago that British Petroleum, then half-owner of the Kuwait concession, and the world's largest oil producer by far, sold more than half a million BOPD of its share of production to its partner, Gulf Oil, at the overlift price, one-eighth way between the accounting cost of production (then about USD 0.80/bbl) and the posted price of USD 1.75. Gulf Oil turned around and resold most of its Kuwait overlift oil at a larger profit, and nobody seemed to care. The world was awash in oil. On the domestic front, supply was so abundant that Texas oil wells were permitted to pump for only 97 days in 1958.

Suffice it to say that we no longer exist in a world of oversupply. West Texas Intermediate (WTI) futures on Nymex briefly crossed the USD 100/bbl threshold in late 2007. Alberta has become the new Kuwait, and the Texas Railroad Commission figuratively relocated from Austin to Vienna and became OPEC. Like the Seven Sisters before them, OPEC has attempted to control the price of oil on world markets, with Saudi Arabia shouldering the role of market regulator. While the majors showed impressive solidarity in their dealings with foreign governments, the supply fundamentals were not in their favor. The nationalization of IPC's holdings in Iraq, for example, was precipitated by the refusal of the majors to develop new Iraqi oil fields when there was already too much oil on the market.

So what has happened to trigger the more than seventy-fold increase in the price of oil since the 1960s, when the arm's-length price of Kuwait crude was around USD 1.35/bbl, and what lessons may we glean from this history as we peer intently into the crystal ball of price predictions?

The Lessons of History

As Winston Churchill famously remarked, "Those that fail to learn from history are doomed to repeat it." Three principal forces have been at play over the past 50 years, and we would be remiss in ignoring them.

1. Population and economic growth, which powered world consumption of refined products to grow from 21.3 to 84.4 million BOPD between 1960 and 2006.
2. Cumulative oil production since 1960, which, notwithstanding published recoverable-reserves estimates to the contrary, exceeded reserves additions.
3. The remarkable adaptability of consumers to higher prices, abetted by frequently undisciplined or short-sighted government policies that encourage inefficient use of transportation fuels.

Oil Consumption. Despite President Bush's label of "oil addict," the US is by no means the only reprobate in the inexorable and seemingly inexhaustible need for oil. **Fig. 1** shows that Asia has been the dominant growth market for oil, with almost six-fold growth in oil consumption since 1965, led by China. Two-thirds of oil demand growth since 1965 has come from outside Europe and North America. Nevertheless, the US still has the highest unit consumption, at 800 gallons per capita of transportation fuels, based on 2004 data. Cumulative consumption of oil products from 1965 to 2006 was 954 billion bbl, of which 61% was from within North America and Europe.

Developing countries play an ever more important role in defining the future as oil consumption is often the driver of economic progress. World population grew by 115% from 1960 to 2006, from 3.04 billion to 6.53 billion people. Of that almost 3.5 billion population increase, 91% came from less developed countries (LDCs), which now account for 81% of the world's population. Any key to understanding the future of oil supply and demand, and therefore of pricing, cannot ignore the demographic fundamentals of the have-nots. The pace at which LDCs are able to transition from subsistence through survival to success is the key to understanding the future of oil.

Reserves and Reserves Additions. Recoverable-reserves figures are a compilation of real and imaginary numbers. As Benjamin Disraeli once said, "There are lies, damned lies, and statistics." Several of the key Middle East producing countries have been accused of manipulating reserves data for any number of reasons, including OPEC quota enhancement

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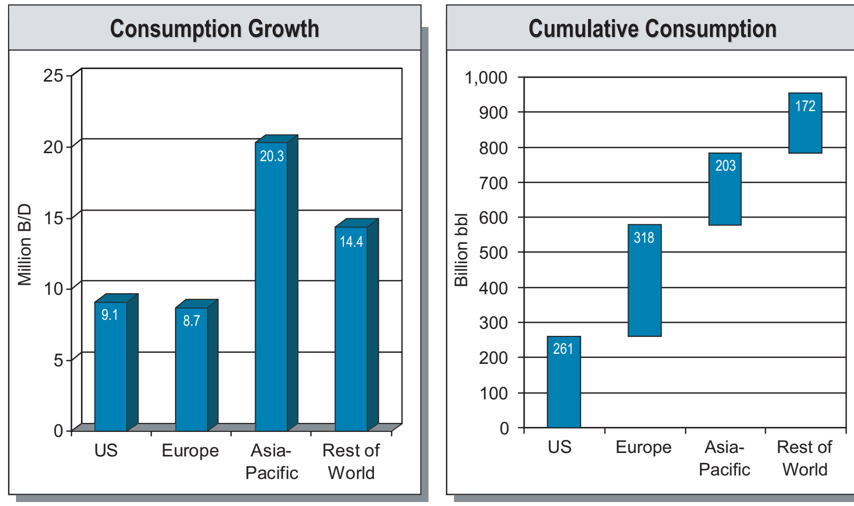
or national security. In 2006, Canadian recoverable reserves increased by at least ten-fold, depending on the source, on account of the inclusion of a larger proportion of the bitumen reserves of the Alberta oil sands. Higher oil prices created an economic incentive to expand oil sands production, and this was reflected in the reserves adjustment. As a result of these adjustments, there is now a dramatic bifurcation in oil security indices (the domestic reserves/consumption ratio) between OPEC and Canada on one hand, and the rest of the world on the other **(Fig. 2).**

Several analysts have pointed to the overstatement of reserves as a warning that the world is in a much more precarious oil supply position than published data might indicate, and that the dreaded peak-oil era is either upon us or nigh. The peak-oil analysts, who base their conclusions on backdating field reserves data to the year of discovery, conclude that net reserves additions started to slow in the mid-1960s, and that world recoverable oil reserves actually peaked at around 1.2 trillion bbl in the late 1970s. Since that time, consumption has far outweighed reserves additions from new discoveries and enhanced oil recovery, with the result that net recoverable reserves are realistically estimated today at around, or somewhat less than, 1 trillion bbl.

The *BP Statistical Review of World Energy* quotes end-2006 proven reserves at 1.208 trillion bbl, excluding a further 164 billion bbl of economic Canadian oil-sands reserves, more than 20% higher than this figure. The net recoverable-reserves figure increased by 541 billion bbl between 1980 and 2006, of which 479 billion bbl were attributed to the OPEC 12 countries. The phantom 479 billion bbl of additional OPEC recoverable reserves (this after cumulative production of 722 billion bbl during that period) implies an annual gross reserves addition of almost 45 billion bbl/yr within OPEC since 1980! This outcome is completely unjustified by the fundamentals.

There is some good news on the resource front, however. Higher oil prices have brought the Orinoco extra-heavy oil belt and the Alberta oil sands front and center as mainline economic prospects. A 2003 US Geological Survey report cites more than 1 trillion bbl of technically recoverable reserves of heavy oil and bitumen, of which nearly 800 billion bbl is located in Canada and Venezuela combined. Only a small fraction of these resources are counted in current proven reserves. It is no exaggeration to conclude that Fort McMurray will one day become the world's next great oil center.



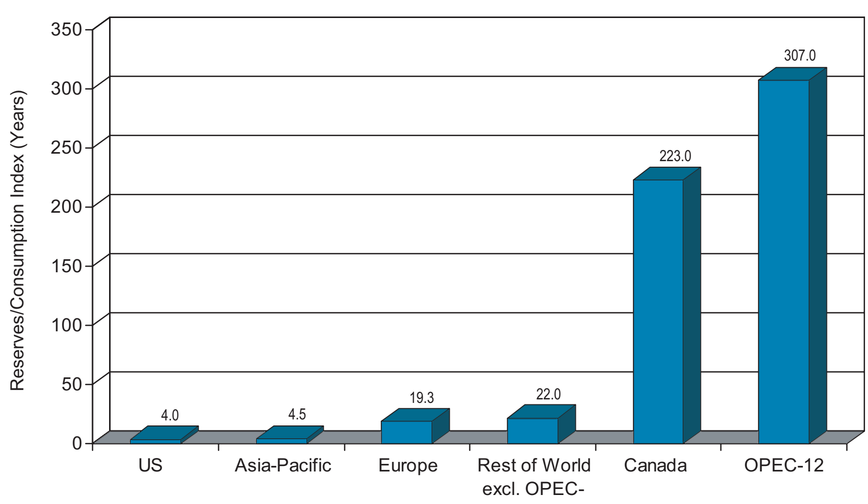
SOURCE: *BP Statistical Review.*

Fig. 1—Oil-products consumption trends, 1965–2006.

Oil Prices and Incentives for Efficiency. If consumption of oil has risen four-fold and per-capita consumption three-fold since 1960, during which time retail transport-fuels prices have grown by orders of magnitude, what practical limits are there to consumers' insatiable demand for transport fuels?

Unlike bulk-oil markets, which are globally integrated, there is no such thing as price discipline at the retail level, where consumer prices are employed more as tools of government policy than they are reflective of supply/demand fundamentals. This is most notably the case for transportation fuels. **Fig. 3** shows some examples of retail gasoline prices from around the world, based on late-2006 data, where there is an almost hundred-fold difference between the highest and lowest pump prices, as a result of widely divergent national policies on the taxation or subsidization of fuels for respective local markets.

While industrial and utility markets have shown resiliency in adapting to the



SOURCE: *BP Statistical Review.*

Fig. 2—Oil security indices, 2006.

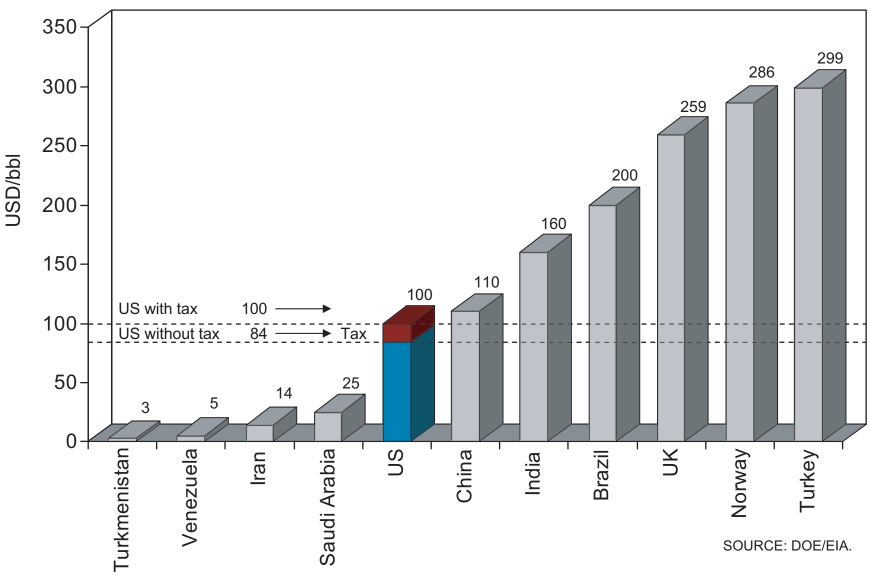


Fig. 3—Retail gasoline prices in selected countries, November 2006.

changing costs and availability of fuels, the traveling public has fewer choices and different criteria for active conservation. The short-term price elasticity of transportation fuels demand is very low, and the impacts of longer-run efficiency influences, including internal-combustion-engine displacement downsizing and high-efficiency diesels and hybrids, have yet to be felt. While the developed world, which has the most capacity for conservation, will doubtless embrace these new technologies over the long haul, the developing world, which will be the engine of growth for this century, has more limited options.

Peering Into the Crystal Ball

There are three overarching influences on the oil price:

1. Population growth in the developing world.
2. The utter reliance of the world economy on liquid fuels for transportation.
3. The development costs of marginal resources.

Population Growth. The most recent U.S. Census Bureau projections estimate that world population will grow from 6.53 billion in 2006 to 8.29 billion by 2030. Of this 1.76 billion more people, 98% of the increase will be in LDCs, while several regions of the OECD will experience declines in population. By 2030, almost 7 out of 8 people will be residents of the developing world. The consequences of this ongoing shift in LDC-driven demographics can result only in increased migration, more skewed wealth distribution, and growing unrest. Barring active social measures to manage population in developing countries, disease and military solutions become the only outcomes. In this future world, where the have-nots increasingly exceed the haves as time goes by, projections of oil consumption are clouded by these greater uncertainties, and seem trivial in comparison to the broader consequences of denying the fuel of economic success to so many.

Transportation-Fuels Demand. Barring global and regional conflicts over resources, a scenario that becomes less unlikely over time, the dominant driver of oil demand in the 21st century is transportation-fuels consumption. As oil prices have risen in real terms and in comparison with other major fuels, oil has increasingly been substituted out of end-uses where its primary value is as a heat source. Thus, oil consumption in industry and power generation is now largely confined to premium applications. Future oil consumption will be directed primarily toward liquid transportation fuels, where the embedded distribution and retailing infrastructure is so vast and costly to replicate for gaseous fuels such as natural gas, or even hydrogen, that it is preferable to convert them to fungible liquids. In addition to liquid transportation fuels, oil demand will continue to support specialty products (such as lubricants, waxes, and asphalt), petrochemical feedstocks (particularly light naphtha), and liquefied petroleum gas (though much of this will be supplied from natural-gas processing). Economic demand for residual fuel and other heavy products, such as coke, will wither in the onslaught of an ever-heavier crude supply barrel and a growing need for bottoms conversion.

Even assuming that North American consumers are able to reduce per capita consumption of transport fuels by 25% to 600 gallons per capita by 2030, the growth in Chinese, Indian, and other LDC consumption of gasoline, diesel, and jet fuel alone swamps this not inconsiderable change in driving behaviors. So long as the freedom to travel is viewed as a personal imperative after the need for food and shelter, emerging economies will increase their consumption of liquid transportation fuels. If we assume that China reaches one-half of western Europe's per capita consumption of transportation fuels by 2030, India reaches one-quarter, and the rest of the non-OECD world grows from 53 gallons per capita to 75 between 2004 and 2030, world transportation-fuels demand would grow from 48.2 million BOPD in 2004 to 84.6 million BOPD by 2030. Adding a conservative 15% additional consumption to reflect other oil products, net of processing gain, implies a minimum crude oil equivalent demand of 97 million BOPD in 2030 **(Fig. 4).**

Other forecasts are not dissimilar. The US Department of Energy's latest world oil demand projection is 103 million BOPD for 2030 in a high oil price environment where crude prices reach USD 100/bbl in 2005 dollars by 2030, and 118 million BOPD in the reference case of USD 59/bbl in real dollars. Even in a scenario of continuing real

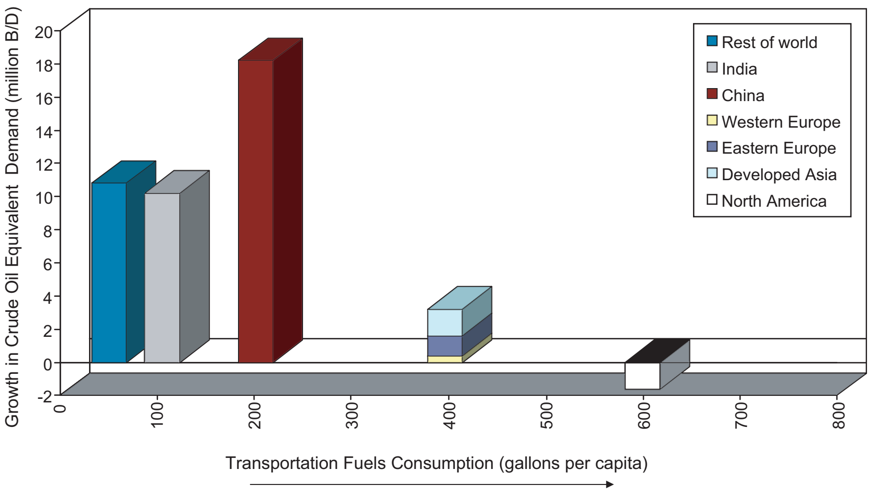


Fig. 4—Projected growth in world crude oil demand, 2004 to 2030.

increases in the price of crude oil, it is going to be hard to hold down consumption growth. When resource depletion is added to the equation, the price outlook gets no rosier from the consumers' perspective.

Marginal Development Costs. In the ideal world of the economists, new oil discoveries would be developed and produced in strict order of their marginal production costs. So long as there is more potential supply than demand, however, new development decisions often rest with surplus-revenue governments that have a yield management choice over when to convert oil reserves into cash. As a result, Saudi Arabia, which has the lowest cost of production, plays the role of marginal supplier. In consequence, high-cost reserves outside the Middle East have been developed even while low-cost Middle East structures are undeveloped or underproduced. This trend is likely to continue, though the capacity of Middle East producers to manage world supply/demand fluctuations will diminish with time.

So what are the major marginal oil supply sources that could fuel continuing demand growth in the face of Saudi development discipline? An answer lies in the value continuum **(Fig. 5).**

At the extremities of the resource supply spectrum exist raw materials that, in their natural state, are not liquids. At one extreme lie coal and bitumen (akin to liquid coal), which are essentially solids and have high sulfur and carbon contents. At the other extreme lies natural gas, whose traditional liquid development options are today limited to gas-to-liquids (GTL) and commodity chemicals. Conversion of coal and natural gas to liquid fuels currently demands syngas conversion linked to Fischer-Tropsch condensation, which is both thermodynamically inefficient and highly capital intensive. Bitumen upgrading can be accommodated by more conventional means, such as coking. In the case of coal and bitumen conversion, the impacts of sulfur and carbon removal are quite costly, when viewed from a full-cycle economics perspective, since massive growth in production of sulfur and CO_2 will necessitate not only sequestration but storage of these byproducts of arguably negative future value. Coke disposition is no less problematical at large scale, which may lead to more integrated bitumen-to-refined products complexes in Alberta to minimize the environmental footprint.

It is these combined technology options of syngas-based GTL and coal to liquids, and coking, which are likely to exert profound influence on the marginal economics of oil supply in the long term. Recent significant increases in the capital costs of these technologies, resulting from capacity pressures imposed on the global engineering, procurement, and construction industry, have caused some marginal upgrading projects to be postponed, such as the more than USD 18 billion ExxonMobil GTL project in Qatar, whose unit capital costs alone require a USD 50/bbl oil price. The capital cost was quoted at USD 7 billion as late as 2004. Elsewhere, massive investments at the margins of the value continuum are planned, as Alberta bitumen producers require some USD 40 to 50/bbl to justify investment in bitumen upgrading to light syncrude or refined products.

In the absence of huge technology investments to bring solids and gases firmly into the domain of liquid fuels, with continuing growth in world demand, and with declining surplus oil reserves in the Middle East, there are no obvious outcomes under which future oil price increases can be contained. The bottom line is that USD 100/bbl oil is here to stay, and double that or more is not inconceivable by 2030. We are still a long way short of oil prices under which transportation is considered a luxury, and wars will be fought over access to oil before that day comes. **JPT**

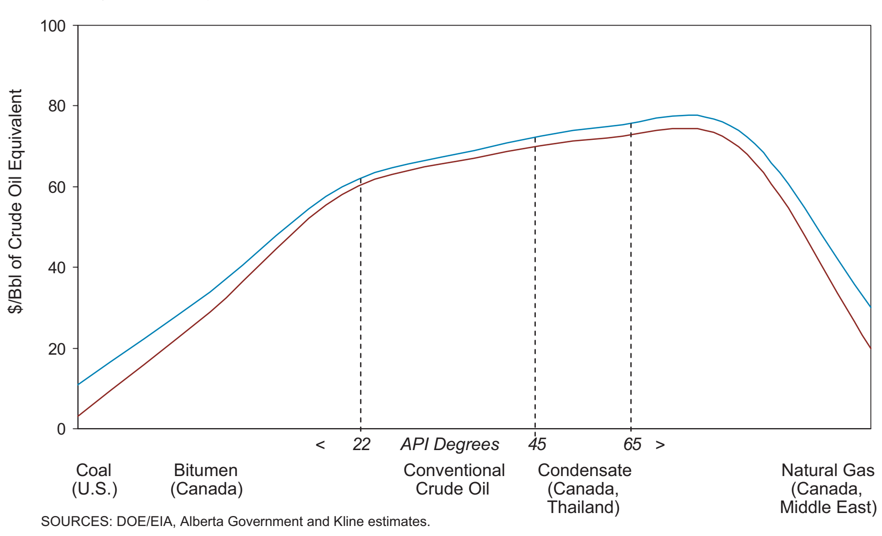


Fig. 5—The value continuum: incentives for upgrading, August 2007.