Why the "Peak Oil" Theory Falls Down

Myths, Legends, and the Future of Oil Resources

DECISION BRIEF®

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WHY THE "PEAK OIL" THEORY FALLS DOWN: MYTHS, LEGENDS, AND THE FUTURE OF OIL RESOURCES

KEY IMPLICATIONS

The peak oil debate continues to rage without any obvious progress. But, upon examination, the peak oil theory falls down because of serious flaws in logic and application. CERA's view, based on two decades of research, is highly unpopular in peakist circles. However, ours is not a view of unlimited resource. A plateau will occur—but not tomorrow, and supply will not "run dry" soon thereafter. We hold that aboveground factors will play the major role in dictating the end of the age of oil.

- Based on a detailed bottom-up approach, CERA sees no evidence of a peak before 2030. Moreover, global production will eventually follow an undulating plateau for one or more decades before declining slowly. Global resources, including both conventional and unconventional oils, are adequate to support strong production growth and a period on an undulating plateau.

- Despite his valuable contribution, M. King Hubbert's methodology falls down because it does not consider likely resource growth, application of new technology, basic commercial factors, or the impact of geopolitics on production. His approach does not work in all cases—including on the United States itself—and cannot reliably model a global production outlook. Put more simply, the case for the imminent peak is flawed. As it is, production in 2005 in the Lower 48 in the United States was 66 percent higher than Hubbert projected.

- The debate should now move toward a better understanding of the key drivers of production, including the scale of global resources and the likely production outlook, which form the core of current disagreements and confusion.

At the same time, there is a need to identify the signposts that will herald the onset of the inevitable slowdown of production growth and ensure that policymakers outside the energy community have a clear understanding of possible outcomes and risks.

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by Peter M. Jackson

INTRODUCTION

In these times of relatively tight supply, high and volatile oil prices, and anxiety about energy security, the peak oil debate is raging once more. This debate reflects one of the most important issues facing not only the energy industry, but the world at large. Those believing in a doomsday scenario argue that peak oil is near and that the world is ill prepared for it. If world oil production were to enter a sharp downward spiral in the next several years, the ramifications for the global economy and geopolitics would be severe and potentially catastrophic.

For many years CERA has maintained a consistent contrary view. CERA does not agree with the simplistic concept of an imminent peak in oil production nor with the idea that oil will "run out" soon thereafter.

Our view is based on our understanding and analysis of fields currently in production and estimates of resources that have not yet been produced or discovered.* CERA believes that technological innovation will continue to unlock additional oil resources not currently identified or understood, or viewed as uneconomic. However, this does not mean that demand for conventional crude oil will always be met with adequate supply. Ours is not a view of endless abundance.

This is a very important debate, and as such it deserves a rational and measured discourse. We respect the urgency and seriousness with which some with whom we disagree put their case. Sometimes, however, the debate gets quite polemical. We wish that this debate could be approached in a more rational and thoughtful manner, buttressed by the recognition that this is subject in which knowledge continues to evolve. A debate based on evidence and dialogue would be more constructive and would certainly better serve the importance of the discussion.

In CERA's recently completed long-term global energy scenarios project, *Dawn of a New Age: Global Energy Scenarios for Strategic Decision Making—The Energy Future to 2030,* four key conclusions emerged regarding liquids supply and demand to 2030.

- **World oil production will not peak before 2030—and the idea of a peak, at least as commonly presented, is itself highly questionable.** In all three scenarios there is no peak in world oil production (including unconventional oil) caused by a lack of belowground resources. Indeed, the concept of a peak in oil production is misleading. When oil production hits a maximum sustainable level, production is likely to be characterized by an "undulating plateau" rather than by a peak followed by a sharp drop-off in output.

*See the CERA Private Report *Expansion Set to Continue—Global Liquids Capacity to 2015.*

- **The global resource base is 4.82 trillion barrels and likely to grow.** CERA's analysis of global reserves and resources includes both conventional and unconventional oils as well as estimates of both field upgrade potential and yet to find. With some 1.08 trillion barrels of cumulative production to date, 3.74 trillion barrels remain, which is three times larger than the typical peakist estimate of 1.2 trillion.

- **Demand may outstrip conventional crude oil supplies.** However, demand for refined products could outstrip *conventional* crude oil production. Conventional crude oil production excludes liquids production from heavy oil sands, ultradeepwater oils, gas-related liquids (condensate and natural gas liquids), gas-to-liquids (GTL), and coal-to-liquids (CTL).* This means that additional sources of liquid fuels will be needed in abundance and in a timely manner, assuming relatively strong global economic and oil demand growth. Technology will promote a widening of the concept of *conventional oil*, as has occurred over the history of the industry.

- **Aboveground risks may limit upstream investments.** An apparent peak in world oil production could appear if aboveground issues—such as war and political changes, or intractability in decision making by governments—limit upstream investment and activity. But such an outcome would not be rooted in a belowground geological constraint in the next few decades. An apparent peak could also be triggered by technological change that substitutes for oil in transportation, capping demand.**

We are also struck by three characteristics of the current debate:

- The peakist argument is not grounded in a credible systematic evaluation of available data.

- The peakist arguments cluster around the questionable model described by the late American geologist M. King Hubbert.*** This is a technique that fails to recognize both that recoverable reserves estimates evolve with time and are subject to constant and often significant change. It also underplays the far-reaching impact of technological advances.

- Some of the peakists are, interestingly, shifting their emphasis away from running out, in terms of physical resources, to issues that we believe are significant—infrastructure and aboveground risks.

In this Decision Brief, CERA examines basic concepts that frame the conversation about future oil resources. Oil is too critical to the global economy to allow fear to replace careful analysis about the very real challenges with delivering liquid fuels to meet the needs of growing economies. We invite others to join in a considered dialogue, which now seems too easily lost in the rancor.

*Although strictly speaking, ultradeepwater oils are compositionally conventional, CERA regards oils produced in the ultradeep water as unconventional.
**See the Break Point Scenario of the 2006 CERA Multiclient Study *Dawn of a New Age: Global Energy Scenarios for Strategic Decision Making—The Energy Future to 2030.*
***M. King Hubbert, 1956. "Nuclear Energy and the Fossil Fuels," American Petroleum Institute, Drilling and Production Practice, pp. 5–75. M. King Hubbert, 1982. "Techniques and Prediction as Applied to Production of Oil and Gas" in S. I. Gass, ed. *Oil and Gas Supply Modeling,* Special Publication 631 (Washington, DC, National Bureau of Standards, pp. 16–141.

HUBBERT: REVISITED AND FOUND INAPPLICABLE

Hubbert set out to predict the future course of US Lower-48 and offshore shelf production. He is credited with predicting the 1970 peak and subsequent decline of US production. Few people realize that his initial estimates were based on a graphical approach. Much later he adopted the logistic approach to develop his previous work and the now famous bell curve.

His methodology predicts that production peaks when approximately half of the resource base of an area base is depleted. Present-day followers of Hubbert's work, such as Kenneth S. Deffeyes, generally imply that the decline cure is symmetrical in time and essentially the mirror image of the growth curve, although Hubbert noted that the curve need not be symmetrical.* This definition may explain why the peakist lobby is so keen to prove why approximately half of global resources have been produced to date.

Hubbert's method also requires an accurate knowledge of the ultimate recoverable reserves of any area. However, numerous studies point to the fact that, during the life of oil fields, resource estimates often increase as understanding of the field improves and new technology is applied. The United States Geological Survey (USGS), notably, points out that reserves growth accounted for 86 percent of total additions to reserves in the United States since 1950 and 86 percent of the additions to reserves in the North Sea since 1985.**

On a different note, Hubbert could never have incorporated the impact of giant discoveries in Alaska nor the deepwater Gulf of Mexico in his 1956 analysis. Therefore he could never have predicted the actual outcome for the US production profile. This resource growth may explain why numerous estimates of the peak of global production have tended to drift into the future. In addition, the method does not incorporate economic or technical factors that influence productive capacity; and, most importantly, it ignores the impact of both price and demand, which are major drivers of production.

Although Hubbert made an important contribution and raised very important questions about future reserves and productive capacity, his methodology simply does not replicate the aggregate production of some 25,000 fields currently producing globally or the impact of new exploration and ongoing field upgrades. The fact that the method works selectively in some areas and not others suggests that it is of limited use and even fundamentally flawed. It is unfortunate that carefully selected elements of his valuable research have been hijacked to help support the peak theory. The debate now needs to shift a gear to closely examine future production using more granular data and a reliable methodology.

PRODUCTION PROFILES

Peakists continue to criticize those who disagree, but their projections of the date of the peak continue to come and go. One of the most recent peak oil dates was supposed to have occurred just after the US Thanksgiving Day 2005, and we still wait for the evidence. In

*K.S. Deffeyes, *Beyond Peak Oil*, Hill and Wang (2005).
**P. J. McCabe, 1998, "Energy Resources—Cornucopia or Empty Barrel?" *American Association of Petroleum Geologists Bulletin*, v. 82, pp. 2110–2134; Klett, T.R., and Gautier, D.L., 2005, "Reserve Growth in Oil Fields of the North Sea," *Petroleum Geoscience,* v. 11, p. 179–190.

addition, there is a whole spectrum of predictions of an imminent peak to choose from (2007–09, 2010, and 2012), but we suspect that these, like so many others, will pass without any explanation. Claims that current high oil prices reflect the fact that the peak has arrived demonstrate a misunderstanding of the fundamentals of supply and demand and the major impact of aboveground risks on current prices. Everything that happens cannot affirm the peak oil theory. How does the 17 percent growth in Chinese oil demand in 2004 prove that a peak is here, any more than the 0.30 percent fall in Chinese oil demand in 2005 proves it? Nor does the complex reserve reporting process driven by US Securities and Exchange Commission (SEC) regulations provide insight into the peak oil question.*

Despite peakists' objections to the contrary view, they still have not taken the opportunity to make available a transparent and detailed analysis that supports their views and that would allow an objective and rational discussion. When all is boiled down, their methodology is to impute decline curves against currently proven reserves and declare that the game—and the argument—are over.

Much of this goes back, of course, to Hubbert (1956) and his subsequent revisions. Some studies as well as work by CERA question the application of the Hubbert principles to the problem.** There are, as noted above, two striking omissions from Hubbert's analysis. First, the underlying premise is that technology is static, which has hardly been the case. Second, Hubbert paid no attention to the impact of revisions and extensions in expanding recoverable oil resources from a typical reservoir.

Simple observation of oilfield behavior shows that the geometry of typical oilfield production profiles seldom reflect Hubbert's curves and are often distinctly asymmetrical even without the application of new technology or enhanced oil recovery techniques. On a much broader scale, Figure 1 shows the actual pattern of US oil production. One would be very hard-pressed to describe this profile as symmetrical in the way the term is normally used. Similarly major, large-scale, mature hydrocarbon provinces (e.g., Mexico and Venezuela) generally do not show a precipitous decline in production after their apparent peak.

Hubbert's analysis of US oil production covered only the Lower 48 and offshore shelf. It is important to appreciate that his outlook was not intended to reflect the forward production profile for the entire United States. We have plotted his projection for the Lower 48 versus actual Lower-48 production since the peak in 1970. He predicted the peak would occur in 1968, within two years of actual in 1970. But his estimate of peak production for 1968 was nearly 600 million barrels per year of oil lower than the actual peak production number (3.517 billion barrels). Actual production of the peak was 20 percent higher than Hubbert predicted.

*See CERA Multiclient Study In Search of Reasonable Certainty: Oil and Gas Reserves Disclosures, the CERA Multiclient Study Modernizing Oil and Gas Reserves Disclosures, and the CERA Decision Brief, China's Demand Slows, but Not for Light Products.

**M. Lynch, 2003, "Petroleum Resources Pessimism Debunked in Hubbert Model and Hubbert Modeler's Assessment," *Oil and Gas Journal,* July 2003.

The impact of resource growth on production has been significant (see Figure 1). By 2005, Lower-48 oil production was some 66 percent higher and cumulative production since 1970 was some 15 billion barrels greater than Hubbert predicted, which represents more than eight years of US production at present rates.

In turn, there is also an important difference between Lower-48 production and total US production between 1970 and 2005—a cumulative 18 billion barrels of oil—or nearly ten years of US production at present rates.

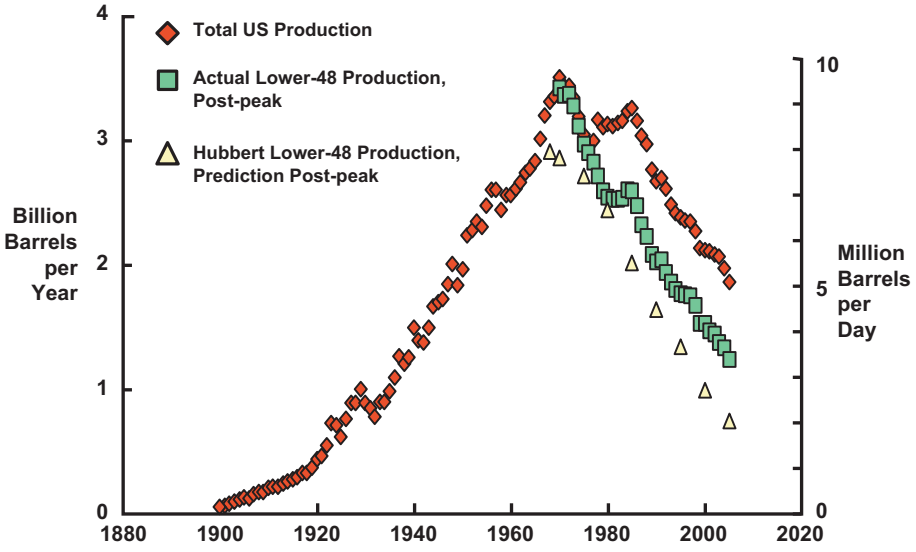
The Changing Production Mix

Our latest liquids capacity outlook, which presents our analysis to 2016, reaffirms our previous conclusion that the beginning of the undulating plateau is not imminent. The only factors that might precipitate the start of a plateau in this time frame would be aboveground and linked to some major global or regional geopolitical meltdown. But this alone would not mean we are running out of oil. Rather, there would be some severe restrictions delivering crude to market because of aboveground factors.

Our analysis points out there are some indications that the rate of growth of conventional oil production capacity is slowing. At the same time, the proportion of unconventional liquids is expanding, resulting in net growth. This apparent slowing of growth in conventional productive capacity may reflect two factors. The first is the lack of real knowledge of what hydrocarbon resources the industry will be developing after 2016, the second is that, at high oil prices, we would expect to see the proportion of unconventional liquids increasing as

Figure 1

United States Production, Hubbert versus Actual



Source: Cambridge Energy Research Associates.
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companies diversify their portfolios away from conventional crudes as a longer-term growth or even survival strategy in a hugely competitive environment. This second factor has the effect of releasing the pressure on the need to grow conventional capacity.

In addition to the expansion of more traditional unconventional sources of liquid hydrocarbons (Canadian oil sands, Orinoco tar sands, ultradeepwater, and gas-related liquids), we are starting to see the emergence of GTL and CTL capacity and a strong emphasis on the development of biofuels. We believe that GTL and CTL collectively may well represent 6 percent of global productive capacity by 2030. In addition the vast resource base represented by shale oil is once again subject to research and development, both in terms of extraction and in terms of solving associated environmental problems, although the timing of any commercial production—if the issues are resolved—appears to be some time off.

Reserves/Resource Definitions and Estimates Cloud the Debate

The debate has been clouded by reserves/resource definitions and unreliable resource estimates. It must be said that reserves and resource analysis is not an exact science, and it is possible to select results to suit a desired argument. Those who believe that a peak is imminent tend to consider only proven remaining resources of conventional oil, which at present they believe to be approximately 1.2 trillion barrels. In the view of many experienced petroleum geologists, this is a pessimistic estimate of remaining recoverable global resources considering the spectrum of hydrocarbon liquids.

The 1.2 trillion barrels figure excludes the enormous contribution likely from probable and possible resources and yet-to-find resources, and plays down the importance of the scale of unconventional reserves and resources embodied in the Canadian oil sands and the Orinoco tar belt—not to mention the oil shale and GTL projects. CERA believes that the global inventory is some 4.82 trillion barrels of resources of which about 1.08 trillion barrels have been produced already. Therefore, there is as much as 3.74 trillion barrels of conventional and unconventional resource remaining, and this order of magnitude of resources will allow productive capacity to continue to expand well into this century (see Table 1 and Figure 2).

The issue of reserves and resources is further complicated by definitions. The SEC's reserve disclosure definitions—originally conceived to meet the security fears of the 1970s—are grounded in the 1965 definitions of the Society of Petroleum Engineers (SPE) and the technology of the 1970s. The SPE is now completing its fourth revision of the definition since then. However, the SEC's guidelines have yet to be revised and are still based on the 1965 definition.

The much-used analysis of Hubbert methodology to predict the peak requires an accurate knowledge of the ultimate recoverable resource of a basin or country. But this is usually never known until the basin or country is almost fully exploited. Technology and knowledge often expand the ultimate recoverable resource of a field or an area. For instance, the total proven reserves of the Alaskan North Slope were, for some years, 9.6 billion barrels. Now, they are 13.7 billion barrels. In CERA's opinion, using reserves as a basis for modeling future productive capacity is not as reliable as grounding the analysis in actual historical

Table 1

Global Resources, Conventional and Unconventional, CERA Projection

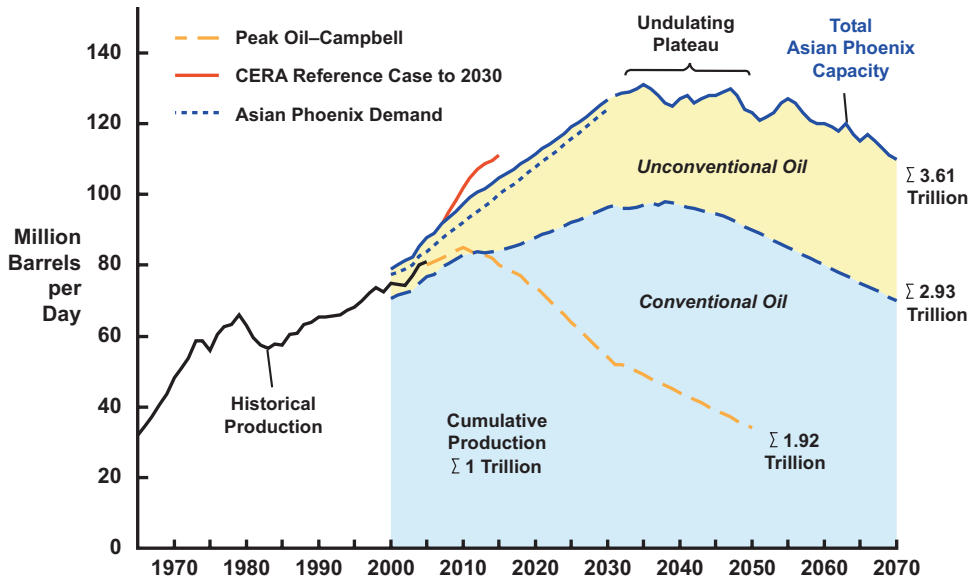
(billions of barrels)

	Cumulative Production	OPEC Middle East	Other Conventional	Deepwater	Arctic	Enhanced Oil Recovery	Extra Heavy	Oil Shale Extract	Exploration Potential	Totals
Rest of the World	813	662	378	50	110	510	277	200	660	3,660
United States	234	—	19	8	5	76	—	500	83	925
Canada	31	—	7	3	3	6	167	4	15	236
Total	**1,078**	**662**	**404**	**61**	**118**	**592**	**444**	**704**	**758**	**4,821**

Source: United States Geological Service, World Petroleum Assessment 2000, Cambridge Energy Research Associates, National Energy Board Canada, IHS Energy.

Figure 2

Undulating Plateau versus Peak Oil



Source: Cambridge Energy Research Associates.
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production data in the context of expected levels of investment and activity. We believe that this approach using real production data reduces the level of uncertainty by an order of magnitude, certainly in the short to medium term.

There are some interesting clues regarding peak oil reflected by the activities of exploration and production (E&P) companies, which do not appear to be behaving as if the peak has arrived. The peakists have emphasized the fact that exploration is not replacing annual production. This is one of the most oft-cited and oft-quoted of their arguments. It is also incomplete and thus misleading. For this point is true only in isolation, as found in analyses done by both CERA and IHS. These analyses show that globally an estimated 6 to 18 billion barrels have been found per year each year between 2000 and 2005 against global production of around 30 billion barrels annually in recent years. Moreover, in isolation, 2005 and 2006 to date look like bad years for the contribution of new resources from discoveries.

But this hides two important points.

- The annual volume of oil discovered in recent years has been relatively low—not necessarily because we are running short of drilling prospects, but rather because it reflects the amount of capital E&P companies are prepared to spend in any one year and the distribution of that expenditure between exploration and development activity.

Capital expenditure on exploration projects is historically low at present compared with development projects, of which as many as 400 new starts are scheduled before 2010. One explanation for this is that, during times of high oil prices, it is prudent from an economic perspective to develop as much oil as possible and not to focus on exploration. There is intense competition among companies to access quality opportunities. Moreover, much of the remaining global exploration potential, which is considerable, is observed in certain OPEC and non-OPEC countries where inward investment is currently restricted and where exploration is not a priority.

- Much of the shortfall in replacement is provided by the upgrade of existing fields, which are currently the focus of most activity. The data set on which our analysis is based is not static, and it can sometimes take months or years for new discoveries or field upgrades to be reported and confirmed. This means that we have to exercise care when extrapolating very recent additions. Here is the key point: If revisions and additions are added to discoveries for the period 1995 to 2003, the combined cumulative growth of supply—320 billion barrels—exceeds production by 80 billion barrels.*

There is no doubt that major new volumes of hydrocarbons would be discovered if exploration capital expenditure increased substantially and if some countries with large volumes of undeveloped reserves started to focus more on exploration by allowing easier access or perhaps by encouraging foreign investment.

Meanwhile we still appear to be in a phase where oil supply (deliverability) is largely determined by demand, economics, and aboveground risks rather than on any fundamental problems with resource availability.

THE UNDULATING PLATEAU

CERA believes that there are five fundamental concepts that are key to understanding the undulating plateau and predicting its arrival.

- **Oil is a finite resource, but there is still no accurate assessment of global reserves and resources.** The peak oil debate hinges on the assertion that remaining global resources of conventional oil are around 1.2 trillion barrels. There is something very interesting about this number. It is a self-fulfilling prophecy. For this number suits exactly the present day application of Hubbert's concept, which incorrectly uses the bell curve. Given that 1.08 trillion barrels have been produced already, according to theory we must be more or less at the global peak. CERA places emphasis on more reliable sources of information (such as the US Energy Information Agency, USGS, and IHS) and believes it is important to incorporate estimates of possible resources, field upgrade potential, exploration potential, and some reflection of the ultimate contribution of unconventional resources. CERA believes that the global ultimate resource base inventory is more like 4.82 trillion barrels, and history tells us that this number is likely to grow, but in our view, at this time, more slowly as time passes.

*IHS Energy.

- **In the recent past, the industry has replaced more oil reserves each year through field reserve upgrades than from pure exploration activity alone, and it has tended to replace production.**
- **Key producing countries such as Saudi Arabia have a vast reserve and resource base.** There is no credible technical analysis that we are aware of that demonstrates that its productive capacity will suddenly fall in the near term.
- **Conventional oil supply will not continue to rise forever; at some stage, the supply of conventional liquids will start to struggle to meet demand.** At some later point in time the growth in unconventional liquid supply will also slow and then stop increasing. Because there is a point at which the supply of conventional liquids struggle to meet demand, unconventional oils and alternative sources of energy will become far more important.
- **The global production profile will not be a simple logistic or bell curve as Hubbert suggested, but will be asymmetrical and strongly skewed past the geometric peak.** In other words, it will look like the undulating plateau, not the peak.

In very broad terms, CERA's concept of the undulating plateau describes a situation where global production of oil supplies reaches an inflexion point. That inflexion point may last some years. Then, global oil production will track a plateau—that may well last for decades—before gradually starting to decline. During this plateau period, the growing demand can no longer be met by available, commercially exploitable natural oil supplies. Nontraditional or unconventional liquid fuels will need to fill in the gap.

CERA's concept of the undulating plateau is nothing more than a reflection of a crest of sorts. But the picture that unfolds is very different from that typically described by the proponents of an imminent peak in oil production. This difference—between a plateau and a cliff—along with the timing of events are the elements of our insight that are critical to the global energy future. Corporations, governments, and other groups, including nongovernmental organizations, need to have a coherent description of how and when the undulating plateau will evolve so that rational policy and investment choices can be made.

Debating only the peak or the plateau will not solve the problem. Moreover, the bitterness and "true believer" nature of the argument have tended to dangerously polarize views. It is essential and more productive to build common understanding and conclusions, open to rational assessment of evidence, so that preparations can be made for the future.

Signposts to Watch

CERA's baseline view of world oil demand and supply does not point to an undulating plateau prior to 2030.* Cycles of both tight and ample supply-demand will continue to occur. If oil prices prove, on average, to be well above the preceding 20 years, that in itself will have an impact on both supply and demand. However, a higher range of prices will more likely be a reflection of aboveground factors.

*See the 2006 CERA Multiclient Study *Dawn of a New Age: Global Energy Scenarios for Strategic Decision Making—The Energy Future to 2030.*

Longer term, we expect the situation to evolve gradually, with clear signposts that will herald the onset of the undulating plateau. There is no unique graphical or analytical process or data set that will allow an accurate and reliable estimate of the scale or timing of the plateau to be made. There is general agreement that a peak or plateau of sorts will develop in the next 50 years, and it is not helpful to couch the debate in terms of a superficial analysis of reservoir constraints. It will be aboveground factors such as geopolitics, conflict, economics, and technology that will shape the outcome.

It is now time to shift the agenda and start to map out the signposts that will help us to recognize and prepare for the time when oil supply could cease to grow adequately to meet demand. This would involve a clear understanding of the main indicators we can extract from geology, economics, technology, and an understanding of supply and demand and oil markets in general. CERA's new Global Scenarios project *Dawn of a New Age* provides one such a framework, and in a subsequent paper we will outline the signposts to look for as we approach the plateau.

THE WAY FORWARD

It is no longer sensible to allow the issues about future supplies to be clouded in a debate grounded in a flawed technical argument about a theoretical peak in global oil production. The peak oil theory certainly stirs passions. It also causes confusion and can lead to inappropriate actions or, worse still, no action. Persistent, but unfulfilled, calls that a global peak is immediate will not lead to rational, long-term investment, policies, and planning. In fact, they may actually spell danger for the future because they will lead to a sense that there is no problem. What we should be developing are those signposts that will provide the clues and indications about the stage the process has reached. These will certainly be clouded in short-term hiccups and the volatility that is endemic to oil markets, but they will appear.

CERA believes that growth in oil supply will slow and stop during the current century. It is also likely that the situation will unfold in slow motion and that there are a number of decades to prepare for the start of the undulating plateau. This means that there is time to consider the best way to develop viable energy alternatives that would eventually provide the bulk of our transport energy needs and ensure that there is a useable production stream of conventional crude and uncoventional oils for some time to come. ■