Oil Scarcity, Energy Security and Long-term Oil Prices—Lessons Learned (and Unlearned)

*By Michael C. Lynch**

Lately, the energy community has been treated to the very entertaining spectacle of catastrophic warnings of imminent petroleum scarcity at the same time that prices are reaching 50 year lows. For a price forecaster, it is somewhat satisfying to see such stark reminders that price does indeed matter, and for a long-time price bear, it is definitely reassuring to see "heresy" prove true. But as an academic, it is disheartening to see the degree to which even the most basic, obvious lessons have gone unlearned, not just by the media, but by people who are supposed to be the experts.

Given the degree to which impending energy scarcity and looming vulnerability to oil crises are being cited both to explain oil company mergers and justify investments in alternative energies, it seems valuable to revisit the issues.

How Did We Get Here?

In the 1970s and 1980s, hundreds of millions of dollars were spent studying the energy crisis by scores of university centers and non-profit research organizations and thousands of individual researchers. Hundreds of books and thousands of articles were written, perhaps fifty major, world-scale studies were performed and at least two dozen computer models of the world oil market were constructed. The analyses were done by oil companies, governments and multinational organizations, as well as environmentalists, consultants and academics, some of whom went on to lead ivy-league business schools and win Nobel prizes for economics. The great majority of this work created a very solid, widely-agreed upon consensus about the nature of the oil crisis and the future direction of oil prices. This consensus not only proved to be wrong but was demonstrably stupid.

Unfortunately, the recent collapse in oil prices, which seems to have caught nearly everyone by surprise, demonstrates that the lessons haven't been learned (or perhaps they aren't even being studied). In the 1986 oil price collapse, there was a bumper sticker seen in Texas reading, "Grant me one more boom and I promise not to screw it up again!" Yet in 1996 and 1997, when short-term market tightness raised oil prices, the industry promptly spent it all, causing the rental rates for drilling rigs to double. Now, with lower prices, financial ratings are plummeting and companies are laying off workers by the thousands, as if they had never seen weak prices before. Perhaps oil companies should diversify into the bumper sticker business.

Forecasting for Fun and Profit (and Maybe Accuracy)

How can so many be so wrong? First, of course, it has to be recognized that there are many rationales for producing or using a long-term forecast. In theory, forecast producers and consumers would want as accurate and unbiased a forecast as possible, but real world practice is another matter. Partly, this reflects the knowledge that no forecast is ever going to be perfectly accurate, and forecast accuracy can be known only long after the fact. Still, even if acquiring an accurate forecast was merely a question of finding the right forecaster or spending enough money, that doesn't mean that it would suit the purposes of all consumers.

Forecasts are often used to determine strategy, policy, and budgets, among other things. As a result, depending on the organization and the person within the organization, there can be strong biases towards either pessimism or optimism. An oil company forecast might be biased towards high prices, because that will raise the value of its stock and justify more investment spending. Alternatively, managers might prefer a low price forecast to encourage cost-cutting. Oil service companies have a natural bias towards price bullishness, since they wish to encourage upstream investment by their customers. Consultants prefer to give their clients what they want (as do academics, all too often).

Similar behavior can be seen in governments, depending on the country (oil importing or OPEC) and the Ministry in question (Finance, Energy, Commerce). Most OPEC governments should be expected to be biased towards optimism about both prices and demand for their oil, although in many cases Finance Ministries and Central Banks tend towards pessimism. Officials in one oil exporting country told me that they preferred conservative production forecasts because their politicians were inclined to overspend projected revenue.

There is also a bureaucratic bias towards conservatism, since most forecasters, given uncertainty about forecast accuracy, will prefer to emulate the consensus. This may not be optimal for their organization, but it is best for them personally, as they are less likely to be punished for producing an inaccurate forecast if it resembles the consensus.

Forecasting Oil Prices

In the early 1990s, there were few articles on price forecasting and an often-implicit consensus around flat prices in the long-term. Yet recently, there has been a resurgence of pessimistic forecasts, with Campbell (1997) leading the charge, and the IEA following along. (DOE has so far resisted the peer pressure.) That these warnings have been wrong before does not, in and of itself, prove their inaccuracy now. (That will be done below.)

Until the mid-1970s, it was common to assume that prices would be flat in the future, although after 1973, they were assumed flat at a much higher level. (See IEA 1977, for example.) But beginning in the late 1970s, as Lynch (1994) showed, many analysts became convinced that real oil prices must inevitability increase, on the order of several percent per year, despite the fact that such trends had never been observed.

These projections have proven to be much too high. The average error for 1997 (before the latest collapse) in the oil price forecasts submitted from the computer models participating in EMF6 (1982) is 540%; for EMF11 (1991), 75%. None was too low. Similarly, at the International Energy Workshop, from 1981 to 1985, 81 of 82 forecasts of 1990 oil prices were too high. Indeed, only a few isolated consultants and academics argued that higher prices were not inevitable. (Lynch 1994 has a more detailed review.)

This rising-price consensus was driven by a combination of factors, including misinterpretations of Hotelling's work as proving that oil prices should rise at the rate of interest and

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OPEC's announced long-term strategy of real price growth matching the trend in OECD economic growth. Both implied (for vastly different reasons) that prices would rise by a few percent per year over the long-term, and so price forecasters assumed such real price growth regardless of external market conditions. Major forecasters like the U.S. Department of Energy repeatedly predicted 3-4% per year oil price increases, even as market conditions varied wildly, and a variety of academics (Pindyck 1978, MacAvoy 1982) argued that natural trends in supply and demand would drive prices upwards. As oil prices fell throughout the 1980s, forecasters who revised their predictions merely lowered the initial point to conform to the new actual level, but continued to predict ever-rising prices.

Forecasting Petroleum Supply

The pattern of errors in forecasts of oil supply may be different, but a pattern there is. Before 1979, many of the oil supply forecasts tended to be too optimistic, often assuming that the 1973 price increase would lead to a substantial non-OPEC production rise. But by 1977, and especially after the Iranian Oil crisis, the psychology shifted. Despite higher oil prices and increased drilling, oil production forecasts were *lowered*, and since that time, nearly all non-OPEC production forecasts have been too low.

To a fair degree, oil supply in the non-OPEC Third World can easily be forecast through extrapolation. However, as I discussed in (Lynch 1996a), the tendency has been to assume that beyond the horizon, production would peak and decline, almost without regard for the geographic location, the maturity of petroleum exploitation (well density, field size, etc.), or the local regulatory regime (taxes and royalties, price controls on crude oil sales, monopoly production by national oil company). It is hard to find a forecast after 1980 that predicts rising production for any region or country but the Middle East and Mexico. Yet except for the United States, oil production has increased consistently in nearly all of these countries.

In fact, almost all forecasts of oil production since the late 1970s have relied on similar arguments: new giant fields are not being found, oil companies are not replacing their reserves, the Middle East contains the bulk of oil reserves, investment is focussed not on exploration but more intensive development of existing reserves, costs are low only because of cyclical depressions in service industries and must, therefore, rise, decline rates are very high in the North Sea and the Gulf of Mexico and investment cannot replace reserves, and new technologies like horizontal drilling will have only a limited application. (Brown et. al. 1979, MacKenzie 1996 as two examples)

Much of this is true, but it has been true for twenty years, yet still non-OPEC production rises. Again and again, forecasters have been forced to raise the projected peak and move it out (the reverse of price forecasting). Inasmuch as these forecasts typically show near-term production peaks in every region, from mature oil producers like the United States to the non-OPEC Third World, which has hardly been touched, it seems clear that the forecasts themselves are inherently biased to produce near-term peaks. Certainly, neither the economics of the industry nor the geological record supports such conclusions. (Lynch 1996b provides evidence of resource abundance.)

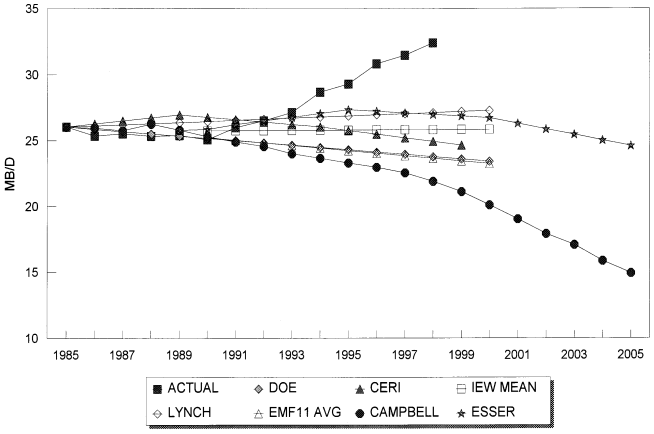
Welcome to the Club (of Rome)

Recent work by Hatfield (1997), Edwards (1997) and particularly Campbell (1997) have predicted the peaking of not just OECD oil production or non-OPEC oil production, but world oil production. Campbell (1997) is the most extreme of these views, arguing that true world oil resources are only 1.8 trillion barrels, significantly less than the 1994 USGS estimate of 2.4 trillion, and only 180 billion barrels remain to be discovered, which results in an approximate production peak this year. Since these authors are all geologists, and published in prestigious journals, including *Nature* and *Scientific American*, their work has received a lot of attention and is assumed credible.

However, as Lynch (1996a) described, the method they use is flawed, treating ultimately recoverable resources (URR) as a fixed point when it is in fact a dynamic variable. It refers not to total resources, but to the recoverable portion of total resources, which naturally increases with changes in technology, infrastructure, price and other factors. The most widely cited estimates, by the USGS, have tended to increase over time, and even Dr. Hubbert, who developed this method, relied on estimates for global oil resources of 1.25 trillion barrels, 20% less than actual discoveries to date.

Although it is too early to measure the validity of the very long-term forecasts of Edwards and Hatfield, Dr. Campbell's work can be assessed, since he has been publishing for ten years. And in fact, his forecasts precisely conform to the predictions of Lynch (1996a), namely, he is too pessimistic, he constantly revises his estimates of URR upwards, and he repeatedly increases the predicted peak production level while always delaying it a few years into the future. Figure 1 shows that his 1991 forecast of non-OPEC oil production was far worse than those of the other major forecasters. The error in his 1991 forecast of non-OPEC, non-FSU production is over 8 mb/d by 1997.

Figure 1
Non-OPEC Production Forecasts
1989/91



And despite Campbell's claims that the accuracy of the database he relies on allows extraordinarily precise estimates of recoverable resources, he has also increased his estimate of URR. His 1991 book estimated global URR at 1.65 trillion

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barrels, and his 1997 book used a figure of 1.8 trillion barrels. The increase of 150 billion barrels is almost exactly the same as oil consumption during that period, implying that he sees the oil industry at a steady state—replacing reserves as fast as they are being consumed—even though he himself does not seem to perceive the implications of his own analysis.

OPEC Market Power and Competitiveness

Thus, most forecasters, such as the International Energy Agency, are clearly exaggerating both the inability of non-OPEC production to increase and our future dependence on the Middle East, as they have done in the past. But even allowing for optimistic views of prices and non-OPEC production (as in Lynch 1996b), there is no question that OPEC market power and the share of oil from the Middle East will grow.

Certainly, the market power of OPEC has improved from the mid-1980s, when prices collapsed. And while most OPEC countries are now focussing on increasing production capacity, rather than stabilizing prices, policies can change. Conceivably, OPEC could become a more effective cartel and raise prices at some point in the future.

But the likelihood that OPEC could regain enough power to duplicate its performance from 1974-1985 seems remote. OPEC oil revenue has declined so dramatically since the late 1970s (and even the mid-1970s) that even the optimistic forecasts do not show revenues reaching the levels of the late 1970s for ten to fifteen years. And current revenues are trivial on a per capita basis when compared to the mid-1970s, approximately one-third of the peak in the early 1980s, and only one-half the level of the mid-1970s. The 8-10% revenue growth which has been projected by the supply pessimists for the past twenty years would restore OPEC's strength fairly soon, but as real revenues have been flat for more than a decade, it seems more likely that the day when OPEC's financial power is restored remains distant.

However, even if renewed OPEC power were a concern, the "solution" to potential future increases in oil prices is not to invest now in expensive energy sources, by subsidizing biomass or geothermal or mandating electric vehicles or other technologies. No question, some technologies are seeing growing market penetration, but their proponents need to adopt much more realistic views of their value and stop relying on arguments about intangible benefits, such as protection from potentially higher prices in the future and reductions in energy insecurity (discussed below).

Pupils, Apt and Inept

Sometimes it feels as if forecasters are harder to train than laboratory mice, given their inability to learn what appear to be fairly clearcut lessons. In fact, the most important lesson is that the consensus can be horribly wrong, that the most well-funded studies, the most prestigious experts, the most August bodies can all produce work which is simplistic and flawed. Although self-interest may have been a factor in some cases (oil companies, environmentalists, etc.), the dominance of the rising-price consensus shows how easily swayed even allegedly independent academic economists can be by fairly superficial arguments that conform to short-term events.

Another lesson is the abundance of bias despite the implication of scientific objectivity. Because data are either unavailable or poor and given the uncertainty about many of the parameters, forecasters are often forced to choose and assume parameters, making it all too easy for an expert to assemble abundant data and citations to support nearly any argument. (Global climate modelers, be warned.)

That there is bias is apparent from two different factors. First, the overwhelming percentage of forecasts whose prices are too high and competitive oil supply forecasts which are too low is proof of forecasting bias. But also, it is abundantly clear that many forecasters are deliberately biased in their work. The repeated citation of Hubbert's successful prediction of the lower-48 U.S. oil production is a good example, since Campbell and others do not mention Hubbert's mistaken prediction that by 2000, world oil production would be 34 million barrels per day and U.S. gas production would be 8 Tcf, both errors exceeding 100%. Similarly, the IEA's treatment of the debate between optimists and pessimists relies heavily on Campbell's work while ignoring work such as Lynch (1996a) which refutes it. (This after arranging for both sides to debate the issues in Paris.)

A common misperception is that forecast errors were due to mindless extrapolation, which failed when trends changed in the 1970s. In fact, forecasting failure has been due to the adoption and defense of bad theories which underlay misspecified models and encouraged the manipulation of forecast components to support those theories. The error in price forecasting is in the reliance on a trend line of 3-4% annual real price increases and the error in oil production forecasting has been the generation of a near-term peak and decline for areas with abundant oil resources. Yet many forecasters have responded to their error by ignoring past errors, retaining the incorrect trend and changing the initial point.

This can be seen in the forecasts from EMF6 and EMF11, which were 10 years apart (1980 and 1990, approximately). The ten world oil models at the former predicted price increases over the subsequent twenty years on average of 3.6% per year, with a range of 1.9-5.3%. The latter forecasts did have lower error rates for 1997, but in truth, they produced nearly identical forecasts for the twenty years following: an average increase of 4.6% per year, and range of 2.1-7.0%. On petroleum supply, Campbell, the IEA, and others, have consistently produced pessimistic forecasts and consistently revised them upwards.

Inasmuch as bees have been proven capable of extrapolation, it would be rather embarrassing to think that energy forecasters are capable of no more than this, the most primitive of methods. But extrapolation has not been the source of forecasting error. If forecasters had extrapolated oil prices from the historical trend of 1870 to 1970, they would have been very wrong from 1974 to 1985, but otherwise, fairly accurate. And extrapolation of non-OPEC, non-U.S., non-FSU production from 1950 would have also generated forecasts far superior to any actually produced.

Of course, extrapolation does not always work. Predicting prices from 1974 to 1985 would require knowledge of cartel theory and OPEC policy, while U.S. oil production has been responding to depletion and rising costs, as well as to price changes (in both directions) and technological advances. This is fortunate, or energy economists could be replaced by spreadsheets.

Energy Insecurity

Some might interpret the above arguments to suggest that energy security is no longer an issue, that there is no likelihood of another oil crisis. However, this misinterprets oil crises as representing oil scarcity and long-term rising prices. In fact, they are short-term price spikes due to oil supply disruptions stemming from political events.

But as with oil price forecasting, there have been numerous warnings of vulnerability and imminent crises, repeated by the same experts again and again for the past twenty years, so that many interpret alarmism about oil crises with the same skepticism that they do Malthusian warnings about long-term oil scarcity.

The Goal of Access

Nations have often worried that they will be denied oil/energy at some critical time, or that the threat of denial will give an opponent political leverage over them. Indeed, Britain, France, Italy and Japan all set up national oil companies, to ensure that they would be able, in the long run, to maintain "access" to oil supplies. To some degree, these moves represented industrial policy, but they have typically been defended as crucial to energy security.

It would be unfair to dismiss these concerns out of hand, even though the number of oil embargoes has been few. Primarily, this is because the oil market has so typically been in surplus that companies, nations and colonial empires sought to encourage the export of petroleum, not use their power to preserve it for themselves. The most famous exception is the Anglo-American oil embargo of Japan in 1941. At that time, the vast majority of the international oil industry was controlled by seven British and American companies which gave their governments' enormous power over world oil trade. These same companies now control only 10% of the world's (non-U.S., non-FSU) production, as opposed to about 90% in 1941.

The Arab Oil Embargoes of 1967 and 1973 are often cited as examples of the political use of oil as a weapon, although the Embargo of 1967 was such a complete failure that few policy makers are aware of it. But even the 1973 Embargo has often been misinterpreted—many recall the price increases, the gasoline lines, and the mad diplomatic scramble for oil, but the embargo on sales which was imposed on the United States and the Netherlands had no practical effect. The oil industry managed to swap supplies of crude from embargoed nations to unembargoed nations, evenly sharing the cutbacks. Prices increased because of the production cutbacks, and gasoline lines were largely the result of consumer panic and government mismanagement.

Policy makers have continually worried that factories would close or citizens go cold because of a lack of oil supply. Yet during both oil crises, factory closings and gasoline lines were rare and short-lived and usually caused by government mismanagement, not a physical lack of oil. True, factories closed and unemployed workers could not afford gasoline, but due to the macroeconomic effects of the oil crises. Inflation levels shot up around the world, two severe recessions were caused, and estimates of lost GNP range into the trillions of dollars. Yet according to those who think that obtaining "access" to oil is the primary energy security goal, there were no crises.

The True Nature of Oil Crises

Some of the experts argue that oil markets are now efficient and that it is better for governments not to interfere during an oil crisis, that oil is not a "strategic commodity". To some degree, this is true. If there is a supply disruption, markets are far more efficient at allocating oil than governments are, although it is often overlooked that markets "clear" through the mechanism of price; if there is no oil to allocate, higher prices reduce demand and thus balance the market. In fact, the implication is that the 1970s events were not oil crises, because markets cleared and the higher prices are just a natural part of that.

But three factors suggest that there remain "strategic" concerns about oil: Oil is valuable, oil is concentrated in politically unstable areas, and oil burns or blows up. Because oil is valuable, it tends to be targeted by labor and/or opposition groups looking for ways to put pressure on their governments. Nowhere is there such a vulnerable concentration of wealth as in an oil pipeline.

The most important difference between a political disruption of supply and a logistical disruption is the uncertainty which the political element causes. Since supply uncertainty is a major driver of hoarding, which has been one of the most important elements in oil market turmoil during the crises of the 1970s, there is a direct, causal connection between politics and oil crises.

There are essentially three components to an oil crisis: a supply disruption, the transformation of the disruption into a crisis, and the economic damage caused by the price increase *in that order*. If a supply disruption can be prevented, no further measures are needed. If it occurs, but can be blocked from developing into a crisis, then all other policy problems are irrelevant. But the last line of defense is to minimize the impact of any crises that occur. Since different policies are useful at different stages, the value of a given approach can be more readily identified by this formulation. A detailed discussion of crisis management policy can be found in Lynch (1998), but here, the question of energy security premiums and the role of alternative energies will be addressed, inasmuch as it relates to the perceived long-term value of different forms of energy.

There are two types of policies which are traditionally advocated to reduce energy security: surge capacity and import minimization. Surge capacity can reduce vulnerability by deterring economic blackmail by oil exporters, and can replace disrupted supplies, which can minimize hoarding. Thus, surge capacity can not only deter some disruptions, but prevent disruptions from turning into a price spike, avoiding economic dislocation altogether without distorting markets.

Import minimization, including energy taxes and subsidies or other assistance for petroleum substitutes, primarily reduces the economic impact of price increases after they have occurred. Reducing oil imports has at best an indirect effect on the size of the disruption, with no impact on the size of surplus capacity. Indeed, by reducing oil exporters' revenue, it could hasten the political upheavals which cause disruptions of oil supplies.

But it is essential to recall that the goal is to reduce economic damage, not to satisfy some primeval urge for fuel. Continually paying twice as much money for solar energy to

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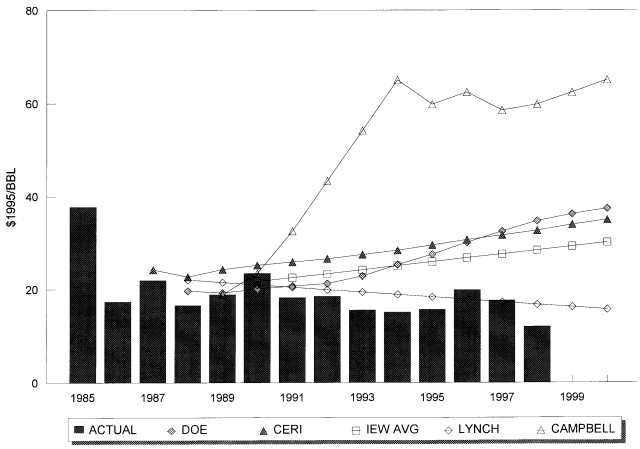
avoid the economic damage from a six month, 50% price spike every ten years is hardly cost-effective. And strategic petroleum reserves are by far the cheapest form of surge capacity. Renewables are usually capital intensive, which is not desirable for back-up capacity, nor are most forms of alternative energies usable in transportation, the primary need during an oil crisis.

The security premium, then, depends on the expectations of the size of future crises and the area under the price spike, which is highly uncertain. In the 1970s, there were two major spikes, in the 1980s, none, and only one moderate one so far in the 1990s. What does this tell us about the probability and size of future oil price spikes? Sadly, not much. But arguments that they will be more prevalent and severe in the future are based more on alarmist concepts than sound evidence.

Expectations

Analyzing recurring errors to recognize theoretical mistakes leads to the simple correction of removing the assumption of peaking oil production and rising prices. This was done in my 1989 publication, which was labeled "heretical" by the *Petroleum Economist* (9/89 p.4) for predicting lower prices in 2000 but has proven moderately accurate. (Figure 2)

Figure 2
1989 Price Forecasts



Many uncertainties remain about oil market developments, including economic growth in Asia, reform in Russia, the role of Iraq, development of Caspian pipelines, as well as OPEC policy, but it is clear that petroleum is abundant and the next decade will see continued price volatility as OPEC struggles to maintain prices. Sadly, the most likely development over the next few years is that billions of dollars will be lost by companies that believe predictions of oil scarcity and rising prices or invest in substitute energies expecting to receive a large security premium.

The surprise is not that oil prices have failed to rise, despite having been predicted to do so by so many experts. And the embarrassing factor is the refusal of so many to recognize their errors and correct them. (Only a few major forecasters, like DOE and the Gas Research Institute, have modified their expectations, for which they are to be applauded.) When hard scientists find that data doesn't match their theory, ignoring the data is not the preferred solution. The theory must be corrected or abandoned. The continued attention to repetitions of forecasts that have persistently proved incorrect is the biggest unanswered question in energy economics.

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