Five Easy Pieces:
» Kjell Aleklett
» Red Cavaney
» Christopher Flavin
» Robert K. Kaufmann
» Vaclav Smil

plus
» Eban Goodstein

on Extinction
and Politics
The world now has over a century's intense experience with oil, the most prized form of energy ever. Oil's benefits are many and undeniable. It accounts for one-third of global energy use and underpins the modern industrial way of life.

But oil is also in crisis. Its long-standing dangers to climate, land use, and human social structures are partly to blame. (If shown the big picture, would our ancestors have paused before rushing into the oil age? Groundwork, p. 30, discusses the precautionary principle.) But the crisis has a new element: we are about to discover what life is like without cheap and abundant petroleum. Global oil production is nearing its peak.

Only a few months ago, the concept of a maximum rate of global oil production was fresh enough to be startling, at least to nonspecialists. Now it is no longer in question among most experts, no matter what point on the spectrum they hail from. The only questions are when the peak will arrive—current estimates seem to be converging on 2010–2020—and what we ought to be doing about it.

On that score, there is considerable argument. The five experts featured here are moderates compared with those who foresee an apocalypse within a year or two, or 10 at the most. While no one can know what 2015 will be like, it's worth remembering that some people find the prospect of civilizational collapse deliciously fascinating.

Our five experts' positions probably bracket the truth. The one unavoidable fact is that oil, a finite resource, cannot economically be pumped out of the ground forever. The approaching peak is a wake-up call. What happens—not when oil runs out, which it never will—but when it becomes very expensive? When we must decide how to allocate this increasingly precious commodity among the many competing uses—transportation, agriculture, the countless artifacts of everyday life—upon which the industrialized world is built?

The transition has begun. As one expert put it at a recent conference, "If the oil age were a party and we went with a six-pack, then we've drunk four beers already." Production from existing fields is dropping about 5 percent per year. Only one barrel of oil is now being discovered for every three or four consumed. Globally, the discovery rate of untapped oil peaked in the late 1960s, and experience with individual fields and oil provinces suggests that peak production lags behind peak discovery by 25–45 years.

So what's the prudent course? The recent history of renewables' growth proves that our energy future is policy driven. On that score, the U.S. government is close to reactionary, but even its own analysis (the "Hirsch Report") has said that we need at least a decade's head start if we want to mitigate the effects of an oil production decline. That means we should be starting...now.

—Tom Prugh, Editor

For more information about issues raised in this story, visit www.worldwatch.org/ww/peakoil.
When I was born in 1945, none of the four small farms in my little Swedish village used oil for anything. Ten years later, the oil age had arrived: we had replaced coal with oil for heating, my father had bought a motorcycle, and tractors were seen in the fields. From 1945 to 1970, Sweden increased its use of energy by a factor of five, or nearly 7 percent per year for 25 years. This journey into the oil age transformed Sweden from a rather poor country into the third wealthiest country (per capita) in the world. Ninety percent of the energy increase came from oil. Cheap oil made Sweden rich.

Now consider China, a developing country with 21 percent of the global population. It consumes 8 percent of the global oil supply, and thinks it is fair to claim 21 percent, or 17.6 million barrels per day (mb/d). During the last five years the average annual GDP growth in China has been 8.2 percent and the average increase in oil consumption 8.4 percent per year. We can now see the same correlation between increase in GDP and use of oil in China as in Sweden 50 years ago. If China’s economy grows 8 percent per year over the coming five years, we can expect that it will need an increase in the consumption of oil of 3 million barrels per day. According to Professor Pang Xiongqi of the China University of Petroleum in Beijing, China’s production will remain level till 2009 and then start to decline. This means that the total increase in consumption must be imported. As China is already importing 3 million barrels per day, it will have to increase imports 100 percent during the next five years. Where will it come from?

Since 2001, when the Association for the Study of Peak Oil & Gas (ASPO) was founded, we have tried to tell the world that there will soon be a problem supplying the world with crude oil while demand continues to rise. The estimated peak-production year at the first depletion workshop in Uppsala in 2002 was 2010. Two years later at our Berlin meeting it had moved to 2008, and now it looks like we are back to 2010, because production from deepwater oil fields will yield more than we expected. The exact year for peak oil depends very much on future demand and we will not know when we have peaked until we have crossed the threshold. It will certainly happen before 2020.

Unfortunately, very few have heeded our alerts, even though the signs have been so obvious that a blind hen could see them. Fifty years ago the world was consuming 4 billion barrels of oil per year and the average discovery rate (the rate of finding undiscovered oil fields) was around 30 billion barrels per year. Today we consume 30 billion barrels per year and the discovery rate is dropping toward 4 billion barrels per year (see figure, p. 12). This is significant; Chevron is even running an ad saying, “The world consumes two barrels of oil for every barrel discovered. So is this something you should be worried about?” (By discovery, I mean only new oil fields. Some analysts include reserve growth—newly accessible oil in old fields—as new discoveries, but we are using the same approach as IEA, the International Energy Agency.)

If we extrapolate the downward discovery slope from the last 30 years, we can estimate that about 134 billion “new” barrels of oil will be found over the next 30 years. The latest large oil field system to be found is the North Sea (in 1969), which contains about 60 billion barrels. In 1999 the North Sea field production peaked at 6 mb/d. Our extrapolation suggests that over the next 30 years we will find new oil fields equal to twice the size of the North Sea—a very pessimistic prediction, according to our opponents. But I think the oil industry would be ecstatic to find two new North-Sea-size oil provinces.

The IEA’s 2004 base-case scenario projects that by 2030 global oil demand will be 121 million barrels per year, which will require increasing production by 37 million barrels per day over the next 25 years, of which 25 mb/d is predicted to come from fields that have yet to be discovered. That is, we’ll have to find four petroleum systems the size of the North Sea. Is this reality?

Every oilfield reaches a point of maximum production, which advanced technologies can delay or extend, but not eliminate. The oil industry and IEA accept the fact that the total production from existing oil fields is declining. According to ExxonMobil, the average production decline rate is between 4 and 6 percent per year. Current global production is 84 million barrels per day, so next year at this time all current fields will produce a total of roughly 80 million barrels.
Crude oil spilled in the Delta region of Nigeria
per day. Given the expected increase in global GDP, one year from now total oil demand will be 85.5 mb/d—so new capacity will have to make up for 1.5 mb/d plus 4 mb/d, or 5.5 mb/d. Two years from now the needed new production will be 11 mb/d and in 2010 at least 25 mb/d. Can the industry deliver? If we extend the decline in existing fields through 2030, and accept the IEA base-case scenario (global demand of 121 mb/d), then “we need new production that is of the order of 10 new Saudi Arabias.” Some might call this a doomsday scenario, but if so I’m not the doomsayer—it’s Sadad Al Husseini, until recently vice-director of Saudi Aramco, the largest oil company in the world.

Excluding deepwater oilfields, output from 54 of the 65 largest oil-producing countries in the world is in decline. Indonesia, a member of the Organization of the Petroleum Exporting Countries (OPEC), not only can’t produce enough oil to meet its production quota, it can’t even produce enough for domestic consumption. Indonesia is now an oil importing country. Within six years, five more countries will peak. Only a few countries—Saudi Arabia, Iraq, Kuwait, United Arab Emirates, Kazakhstan, and Bolivia—have the potential to produce more oil than before. By 2010, production from these countries and from deepwater fields will have to offset the decline in 59 countries and the increased demand from the rest of the world.

Can they do it? Let’s look at Saudi Arabia, which in the early 1980s produced 9.6 million barrels per day. According to the IEA and the U.S. Energy Information Administration, Saudi Arabia must produce 22 mb/d by 2030. But Sadad Al Husseini claims that “the American government’s forecasts for future oil supplies are a dangerous over-estimate.” The Saudi Ghawar oil field, the largest in the world, is in decline. Saudi Aramco says that production can be increased to 12.5 mb/d in 2015. They plan a new pipeline with a capacity of 2.5 mb/d, so it looks like they are willing to increase production to 12.5 mb/d, but so far there are no signs of reaching 22 mb/d.

Now consider Iraq, which in 1979 produced 3.4 mb/d. Iraq officially claims reserves of 112 billion barrels of crude oil, but ASPO (and other analysts) think that one-third of the reported reserves are fictitious “political barrels.” At a recent meeting in London, I was told (privately, by a person who is in a position to know) that Iraqi reserves available today for production total 46 billion barrels. If this is the case, it will be hard for Iraq to reach its former peak production level in a short time.

And so on. It’s time to ask, can the Middle East ever again produce at the peak rates of the 1970s?

Many countries in the world are very poor. It may be necessary to double global GDP to achieve any kind of decent life for people in these countries. The examples of Sweden and China suggest that, if past economic development patterns are followed, doubling GDP will require doubling global oil production. Can this even be done? And can the planet tolerate the increase in CO2 emissions?

The United States, the wealthiest country in the world, has 5 percent of the global population and uses 25 percent of the oil. It is time to discuss what the United States should do to cut consumption—and rapidly. In February 2005 a report for the U.S. Department of Energy (Peaking of World Oil Production: Impacts, Mitigation, and Risk Management, aka the Hirsch Report) argued that “world oil peaking represents a problem like none other. The political, economic, and social stakes are enormous. Prudent risk management demands urgent attention and early action.” Any serious program launched today will take 20 years to complete.

Animals that face food shortages have a hard time adjusting, and usually their populations decline. Some believe that we as human beings will face a similar situation. I can’t accept that. As human beings we can think and come up with ideas, and I believe we can find solutions. The road will be bumpy and many people will be hurt, but when we arrive at the end of this road it must be as a sustainable society. It will not be possible to travel this road without using part of the existing stocks of fossil fuels and, for industrial countries, nuclear energy as well, but we can do it in a manner that will have minimal impact on the planet. We should have started at least 10 years ago. We must act now, as otherwise the bumps and holes in the road might be devastating.

Kjell Aleklett is Professor of Physics at Uppsala University, Sweden, and President of the Association for the Study of Peak Oil & Gas.
Once again, we are hearing that world oil production is “peaking,” and that we will face a steadily diminishing oil supply to fuel the global economy. These concerns have been expressed periodically over the years, but have always been at odds with energy and economic realities. Such is the case today.

Let’s look at some history: In 1874, the chief geologist of Pennsylvania predicted we would run out of oil in four years—just using it for kerosene. Thirty years ago, groups such as the Club of Rome predicted an end of oil long before the current day. These forecasts were wrong because, nearly every year, we have found more oil than we have used, and oil reserves have continued to grow.

The world consumes approximately 80 million barrels of oil a day. By 2030, world oil demand is estimated to grow about 50 percent, to 121 million barrels a day, even allowing for significant improvements in energy efficiency. The International Energy Agency says there are sufficient oil resources to meet demand for at least the next 30 years.

The key factor here is technology. Revolutionary advances in technology in recent years have dramatically increased the ability of companies to find and extract oil—and, of particular importance, recover more oil from existing reservoirs. Rather than production peaking, existing fields are yielding markedly more oil than in the past. Advances in technology include the following:

Directional Drilling. It used to be that wellbores were basically vertical holes. This made it necessary to drill virtually on top of a potential oil deposit. However, the advent of miniaturized computers and advanced sensors that can be attached to the drill bit now allows companies to drill directional holes with great accuracy because they can get real-time information on the subsurface location throughout the drilling process.

Horizontal Drilling. Horizontal drilling is similar to directional drilling, but the well is designed to cut horizontally through the middle of the oil or natural gas deposit. Early horizontal wells penetrated only 500 to 800 feet of reservoir laterally, but technology advances recently allowed a North Slope operator to penetrate 8,000 feet of reservoir horizontally. Moreover, horizontal wells can operate up to 10 times more productively than conventional wells.

3-D Seismic Technology. Substantial enhancements in computing power during the past two decades have allowed the industry to gain a much clearer picture of what lies beneath the surface. The ability to process huge amounts of data to produce three-dimensional seismic images has significantly improved the drilling success rate of the industry.

Primarily due to these advances, the U.S. Geological Survey (USGS), in its 2000 World Petroleum Assessment, increased by 20 percent its estimate of undiscovered, technically recoverable oil. USGS noted that, since oil became a major energy source about 100 years ago, 539 billion barrels of oil have
Advances in drilling technology make it possible to recover oil and gas not previously considered recoverable in the initial reserve estimates.

Enhanced oil recovery techniques increase the recovery factor for oil and thereby increase the reserves within existing fields.

Here in the United States, rather than “running out of oil,” potentially vast oil and natural gas reserves remain to be developed. According to the latest published government estimates, there are more than 131 billion barrels of oil and more than 1,000 trillion cubic feet of natural gas remaining to be discovered in the United States (see map, p. 13). However, 78 percent of this oil and 62 percent of this gas are expected to

been produced outside the United States. USGS estimates there are 649 billion barrels of undiscovered, technically recoverable oil outside the United States. But, importantly, USGS also estimates that there will be an additional 612 billion barrels from “reserve growth”—nearly equaling the undiscovered resources. Reserve growth results from a variety of sources, including technological advancement in exploration and production, increases over initially conservative estimates of reserves, and economic changes.

The USGS estimates reflected several factors:

- As drilling and production within discovered fields progresses, new pools or reservoirs are found that were not previously known.
- Advances in exploration technology make it possible to identify new targets within existing fields.
- Advances in drilling technology make it possible to recover oil and gas not previously considered recoverable in the initial reserve estimates.
- Enhanced oil recovery techniques increase the recovery factor for oil and thereby increase the reserves within existing fields.

Repairing an oil-well pump, Iraq
warming our homes, and getting us where we need to go. Here in the United States, oil provides about 97 percent of transportation fuels, which power nearly all of the cars and trucks traveling on our nation’s highways. And plastics, medicines, fertilizers, and countless other products that extend and enhance our quality of life are derived from oil.

In considering our future energy needs, we also need to understand that gasoline-powered automobiles have been the dominant mode of transport for the past century—and the overwhelming preference of hundreds of millions of people throughout the world. Regardless of fuel, the automobile—likely to be configured far differently from today—will remain the consumer’s choice for personal transport for decades to come. The freedom of mobility and the independence it affords consumers is highly valued.

The United States—and the world—cannot afford to leave the Age of Oil before realistic substitutes are fully in place. It is important to remember that man left the Stone Age not because he ran out of stones—and we will not leave the Age of Oil because we will run out. Yes, someday oil will be replaced, but clearly not until substitutes are found—substitutes that are proven more reliable, more versatile, and more cost-competitive than oil. We can rely on the energy marketplace to determine what the most efficient substitutes will be.

As we plan for our energy future, we also cannot afford to ignore the lessons of recent history. In the early 1970s, many energy policymakers were sure that oil and natural gas would soon be exhausted, and government policy was explicitly aimed at “guiding” the market in a smooth transition away from these fuels to new, more sustainable alternatives. Price controls, allocation schemes, limitations on natural gas, massive subsidies to synthetic fuels, and other measures were funded heavily and implemented.

Unfortunately, the key premises on which these programs were based, namely that oil was nearing exhaustion and that government guidance was desirable to safely transition to new energy sources, are now recognized as having been clearly wrong—and to have resulted in enormously expensive mistakes.

Looking into the distant future, there will be a day when oil is no longer the world’s dominant energy source. We can only speculate as to when and how that day will come about. For example, there is an even bigger hydrocarbon resource that can be developed to provide nearly endless amounts of energy: methane hydrates (methane frozen in ice crystals). The deposits of methane hydrates are so vast that when we develop the technology to bring them to market, we will have clean-burning energy for 2,000 years. It’s just one of the exciting scenarios we may see in the far-off future. But we won’t be getting there anytime soon, and until we do, the Age of Oil will continue.

Red Cavaney is President and Chief Executive Officer of the American Petroleum Institute, an industry trade group.
As oil prices soared from $24 per barrel in early 2003 to a peak of $70 per barrel in September 2005, the question being asked by experts and policy makers alike was whether we’ve “entered a new era,” as Chevron Corporation CEO David O’Reilly has said, or just encountered a temporary glitch that will be corrected by market forces, as ExxonMobil President Rex Tillerson argued in a speech to the World Petroleum Congress last September.

The most intriguing thing about this raging debate over whether oil production will soon peak—and put an end to the go-go days of the petroleum age—is that it’s occurring at all. The fact that a century into the age of oil, and with the global economy dependent on $3 trillion worth of this black liquid each year, we don’t know how much is left, is extraordinary.

It turns out that most of the forecasters who are responsible for the long-term energy projections on which private and public decision makers rely—from Wal-Mart to the International Energy Agency—have been on automatic pilot, assuming that whatever the future level of demand, the oil companies will be able to extract sufficient oil to meet it. You don’t have to be a card-carrying member of the “peak oil” school that has gathered behind former Shell geologist Colin Campbell to see that this is a dangerous assumption.

One fact is undeniable: over the past decade, oil production has been falling in 33 of the world’s 48 largest oil producing countries, including 6 of the 11 members of OPEC. In the continental United States, the world’s oil pioneer, production peaked 35 years ago at 8 million barrels per day, falling to less than 3 million barrels per day now. Among the other major oil-producing countries where production is declining are the United Kingdom and Indonesia.

Those who take a more sanguine view of the global oil prospect point to the 1.1 trillion barrels of “proven” reserves that are currently on the books of the world’s oil companies—equivalent to all the oil extracted over the past century, or more than 40 years of consumption at the current rate. Although those same figures appear in most official oil reports, it turns out that roughly three-quarters of the world’s oil is controlled by state-owned companies, whose reserve figures are never audited and are based as much on politics as on geology. Many countries have added paper barrels to their reserves at times they weren’t even looking for oil.

Since oil can’t be extracted unless it is found, one of the most persuasive arguments that oil production is nearing its peak is that oil extraction has exceeded discoveries by a factor of three during the past two decades. This is clearly a trend that cannot continue. PFC Energy, an oil industry consulting firm, has recently analyzed these figures and concluded that non-OPEC oil production will peak within five years, and that OPEC production could peak within another five years. Chevron Corporation is among those that have argued that nearly half the world’s exploitable oil has already been extracted.

The largest wild card facing the future of oil is the Middle East, where highly secretive state-owned companies have kept silent on the condition of their vast oil fields for the last 30 years. Contrary to the popular myth that their oil resources are so vast as to flow freely from the Earth wherever a hole is punched, papers published by Saudi engineers indicate that massive water injection and other forms of secondary recovery are now needed to keep the oil flowing. A handful of 30–50-year-old oil fields supplies most of the nearly 10 million barrels of oil that Saudi Arabia produces each day, and hardly any new fields have been discovered in the last two decades. Late last year, U.S. intelligence analysts questioned whether Saudi Arabia can even meet its near-term pledge to raise production modestly, let alone achieve the massive increases that many oil-consuming countries appear to be counting on.

Those who live by the crystal ball often end up eating ground glass, so I won’t join those in the peak oil school who have predicted which month world oil production will peak. But there’s one conclusion on which I’m ready to stake my reputation: the current path—continually expanding our use of oil on the assumption that the Earth will yield whatever quantity we need—is irresponsible and reckless.

The first step in getting off that path is to agree that far greater transparency is needed on the part of oil-exporting companies and governments. Just as commercial aircraft cannot land at international airports unless they meet accepted
Oil pipelines in Alberta, Canada
which is beginning to attract the same kind of buzz that surrounded John D. Rockefeller’s feverish expansion of the oil industry in the 1880s—or Bill Gates’s early moves in the software business in the 1980s. Indeed, in the last year, new energy technologies have been almost as popular with Silicon Valley venture capitalists as the latest Internet software.

These “new renewables” now provide just 2 percent of the world’s energy, but as the computer industry discovered decades ago, double-digit growth rates can rapidly turn a tiny sector into a giant. Brazil already gets over 40 percent of its light transportation fuel from ethanol derived from sugar cane, and studies in the United States indicate that this largest of all oil consumers could grow well over half its liquid fuels using advanced new technologies that are expected to be commercialized in the next decade.

None of this is to say that the transition away from oil will be easy. Energy prices are likely to rollercoaster in the years ahead, disrupting the world economy, and making it difficult to smoothly plan the development of alternatives. But crises often create opportunities, and the potential rewards from an energy transition are substantial indeed: creating whole new industries, particularly in developing countries; reviving agricultural markets and strengthening rural economies; and pinching off the money pipeline that is destabilizing the Middle East.

But there is another danger surrounding a potential peak in world oil production: the impact on global warming. Some have argued that a forced march away from oil will push the world economy into dependence on fuels that add even more carbon dioxide pollution to the atmosphere: oil shale, tar sands, and coal, all of which are extremely abundant—and dirty.

That danger is real. High oil prices make it more economical to turn these carbon-based fuels into liquids, and if they receive heavy subsidies while the cleaner alternatives are starved, we may be facing an ecological crisis as well as an economic one. On the other hand, if rising oil prices give a serious boost to investment in energy efficiency, public transportation, biofuels, and other renewable energy sources, they could jumpstart the energy transition that is needed to solve the climate emergency now facing the world.

One point is inarguable: a century after the oil age began in earnest, humanity faces an historic test. Human ingenuity is one resource that won’t peak—but whether it can be mobilized quickly enough to surmount these challenges is not yet clear.

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Planning for the Peak in World Oil Production

By Robert K. Kaufmann

You will never wake to the headline, “World Runs Out of Oil.” Rather, global oil production will rise, reach one or more peaks, and decline. Well before production declines to very low levels, the peak will mark a point of no return that will be a watershed in the economic history of the 21st century. For the first time, industrial economies will be forced to a lower-quality energy source. And this decline will affect every aspect of modern life.

The notion of a world speeding towards a peak in oil production was made famous by the geologist M. King Hubbert. In the late 1950s and early 1960s, Hubbert used a simple bell-shaped curve to forecast the annual rate of production in the lower 48 U.S. states (see figure). At a time when oil production was increasing rapidly, Hubbert forecast that it would peak in about a decade (1965–1970) and decline thereafter. Despite provoking nearly unanimous derision, his forecast was remarkably accurate. Oil production peaked in 1970 and declined fairly steadily thereafter. A similar bell-shaped pattern appears in several other oil producing nations, such as Norway, the United Kingdom, and Egypt.

Subsequent research indicates that Hubbert’s forecast was part genius and part luck. U.S. oil production is determined by the costs of production, the price of oil, and the quantity of oil “shut in” by the Texas Railroad Commission, which aimed to stabilize prices by opening and closing oil wells in Texas to ensure a balance between supply and demand from the 1930s through the early 1970s. Had prices evolved over some alternative path or had the Commission controlled production using some other criterion, Hubbert’s prediction probably would have been less accurate.

The element of luck has been overlooked by those who use Hubbert’s method to forecast the peak in global oil production. Their forecasts have consistently erred, suggesting an imminent peak, only to be revised when production continued to rise after the predicted date. Hubbert’s methodology cannot predict the peak in global oil production because it mistakes the price-induced slowing of oil consumption during the 1970s and 1980s for the effects of resource depletion.

The genius in Hubbert’s approach stems from a simple aspect of his bell-shaped curve: relatively large uncertainties about recoverable oil supply have relatively little effect on the timing of the peak. For example, updating Hubbert’s analysis through 2003 and including Alaskan production indicates that about 230 billion barrels will be produced from fields in the United States, which is nearly 30 percent more than Hubbert’s original estimate of 171 billion barrels. Despite this increase, the timing of the peak “backcast” hardly changes. Put simply, compared to pessimistic assessments, optimistic estimates for the amount of oil that remains only postpone the peak slightly.

Given this fact, I can confidently state that the peak in global oil production will occur in my lifetime (I am 48).

The peak in global oil production marks a fundamental change in supply. Prior to the peak, production can increase...
significantly with little or no increase in price (see figure). This is possible because most of the world’s supply is found in a few very large fields. For example, there are more than 14,000 oil fields in the United States. Of these, the largest 100 contain nearly 40 percent of total supply. Increasing production from these large fields is relatively inexpensive. But once these large fields are depleted, they are replaced with fields that are one-tenth or one-hundredth their size. These high-cost fields reduce the profitability of production even at higher prices.

The importance of production costs is illustrated by the history of U.S. production. Oil production in the lower 48 states increased more than ten-fold between 1900 and 1970, but the real price of oil barely increased. After 1970, real oil prices doubled and then tripled. This price increase caused drilling to double. Nonetheless, production declined nearly 20 percent. As a result, the oil and gas sector increased its fraction of national investment without increasing its contribution to GDP—in effect, hundreds of billions of dollars were flushed down a dry hole.

The economic effects of the peak go beyond spending more at the pump. Because oil readily comes from the ground and is easily refined, it generates a large “energy surplus,” which is the difference between the energy obtained and the energy used to obtain it. The large energy surplus powers the non-energy sectors of the economy, such that goods can be imported and exported at little extra cost, people can live far from work, and a small fraction of the workforce can feed those that produce the goods and services we associate with modernity. All of this may change following the global peak in oil production. After the peak, each barrel of oil will require more energy to extract, leaving less to power the non-energy sectors of the economy.

No alternative fuel now being researched generates a greater surplus or can be used more efficiently than oil. This reduction in the energy surplus differentiates the peak in global oil production from previous energy transitions. As society changed from wood to coal and from coal to oil, each new energy resource was “better” than its predecessor. It could be used more efficiently and it generated a greater surplus.

This creates an additional difficulty for the inevitable transition away from oil. Alternative fuels can generate an energy surplus large enough to power the U.S. and world economies, but to do so the infrastructure for the alternative fuel needs to be larger than the current oil infrastructure. If 1 Btu (British thermal unit) of oil could be used to extract 50 Btu of new oil from the ground (which was the ratio at the U.S. peak), most alternatives currently produce 2–10 Btu per Btu invested. The infrastructure for such alternatives would need to be five to twenty-five times larger than the current oil infrastructure.

The expanded infrastructure requires a timely transition. If the infrastructure for the alternative energy source is put in place before the peak arrives, the energy used to do so will have a relatively small impact on non-energy sectors. Conversely, if society waits until the peak, constructing the large infrastructure for the alternative fuel will siphon large amounts of energy from the non-energy sectors of the economy at the very time that the total supply and energy surplus from oil is shrinking. In short, society has to pay the costs for the transition. We can pay them now, while we have oil in the bank, or we can pay them later, when our oil bank account is emptying.

Economists often assure us that the competitive market will induce the needed investments in a timely fashion. I am less sanguine. The markets’ ability to anticipate the timing of the peak and the rate of decline is limited by a lack of transparency in the world oil market. Estimates from the Organization of the Petroleum Exporting Countries (OPEC) of its proven reserves are a mix of geology and politics. This uncertainty is critical because much of the oil produced between now and the peak (and beyond) will come from OPEC. As such, the market cannot know how much oil remains and therefore cannot cause prices to rise in anticipation of the peak.

The market therefore needs help to ensure that the entrepreneurial spirit will manage the transition from oil. But not the kind embodied in the Energy Policy Act of 2005. No serious person can believe that it will help. The current bill demonstrates that Republicans and Democrats have the same view of energy policy: they just give tax money to different groups. Sound policy should instead establish an economic environment that increases the economic returns and reduces the risk to long-term research and development on alternative energies. Policy should impose a large Btu or carbon tax on energy that is phased in over a long period, perhaps 20 years. This would signal entrepreneurs that there will be a market for alternative energies. Furthermore, increases in the energy tax should be offset by reducing other taxes, such as payroll or corporate taxes. Economic studies show that such
natives in place at the time of the peak will have tremendous economic and social consequences. So if society does too much now to stimulate alternative energies, as opposed to later, there will be some loss of economic efficiency. But if society does too little now, as opposed to later, the effects could be disastrous. Under these conditions, doing too little now in the name of economic efficiency will appear in hindsight as rearranging deck chairs on the Titanic.

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an approach can generate a win-win solution—reduce energy use (and the environmental damages not paid by users), stimulate research and development on alternative energies, and speed economic growth. Notice that the tax does not pick technologies—that will be left to the market, which is smarter than any politician (or economist!)

Government policy aimed at the next energy transition must strive for economic efficiency, but efficiency cannot be the sole criterion. The potential for large impacts may force policy makers to rely heavily on the precautionary principle (see p. 30), which compares the costs of being correct against those of being incorrect. We know that oil production will peak within our lifetime, we are pretty sure that market prices will not anticipate this peak, and we know that not having alternatives in place at the time of the peak will have tremendous economic and social consequences. So if society does too much now to stimulate alternative energies, as opposed to later, there will be some loss of economic efficiency. But if society does too little now, as opposed to later, the effects could be disastrous. Under these conditions, doing too little now in the name of economic efficiency will appear in hindsight as rearranging deck chairs on the Titanic.
Peak Oil: A Catastrophist Cult and Complex Realities

By Vaclav Smil

Proponents of the imminent peak of global oil extraction—led by Colin Campbell, Jean Laherrère, L.F. Ivanhoe, Richard Duncan, and Kenneth Deffeyes—resort to deliberately alarmist arguments as they mix incontestable facts with caricatures of complex realities and as they ignore anything that does not fit their preconceived conclusions in order to issue their obituaries of modern civilization. Ivanhoe sees an early end of the oil era as “the inevitable doomsday” followed by “economic implosion” that will make “many of the world’s developed societies look more like today’s Russia than the U.S.” Duncan’s future brings massive unemployment, breadlines, homelessness, and a catastrophic end of industrial civilization.

These conclusions are based on interpretations that lack any nuanced understanding of the human quest for energy, disregard the role of prices, ignore any historical perspectives, and presuppose the end of human inventiveness and adaptability. I will raise just three key points aimed at dismantling the foundations of this new catastrophist cult. First, these preachings are just the latest installments in a long history of failed peak forecasts. Second, the peak-oil advocates argue that this time the circumstances are really different and that their forecasts will not fail—but in order to believe that, one has to ignore a multitude of facts and possibilities that readily counteract their claims. Third, and most importantly, there is no reason why even an early peak of global oil production should trigger any catastrophic events.

The modern tradition of concerns about an impending decline of resource extraction began in 1865 with Victorian economist William Stanley Jevons (1835–1882), who concluded that falling coal output must spell the end of Britain’s national greatness as it is “of course…useless to think of substituting any other kind of fuel for coal.” Substitute oil for coal in the last sentence and you get the erroneous foundations of the doomsday sentiment shared by the peak-oil catastrophists. There is no need to elaborate how wrong Jevons was. The first half of the 20th century had its share of peak forecasts but Jevonian sentiment was forcefully reintroduced by M. King Hubbert with his correct timing of the U.S. oil production (minus Alaska!). This feat led the peak-oil groupies to consider Hubbert’s Gaussian exhaustion curve with the reverence reserved by the Biblical fundamentalists to Genesis.

In reality, it is a simplistic “geology-only” model based on rigidly predetermined reserves and ignoring any innovative advances or price shifts.

Not surprisingly, it has repeatedly failed. Hubbert himself put the peak of global oil extraction between 1993 and 2000. In 1977 the Workshop on Alternative Energy Strategies forecast the global oil peak as early as 1990 and most likely between 1994 and 1997. In 1979 the U.S. Central Intelligence Agency believed that global output must fall within a decade. In the same year British Petroleum, the world’s second largest oil company, predicted the world production peak in 1985 and the total output in the year 2000 nearly 25 percent below that maximum. In reality, global oil output in the year 2000 was nearly 25 percent above the 1985 level! Some of the latest peak-oil proponents have already seen their forecasts fail: Campbell’s first peak was to be in 1989, Ivanhoe’s peak was in 2000, Deffeyes had it in 2003 (and now, ridiculously, on Thanksgiving 2005). But they would argue that this makes no difference as that inevitable event will take place within months or years. Moreover, they claim that matters are now entirely different.

They are convinced that exploratory drilling has already discovered some 95 percent of the oil originally present in the Earth’s crust and that nothing we do, be it SUV replacements or new offshore drilling, can help us to avoid a bidding war for the remaining oil. And, so we are repeatedly told, “the oil era is over.” But in chanting this patently false mantra the devotees continue to ignore several fundamental facts.

True, there is an unfortunate absence of rigorous international standards in reporting oil reserves and many official totals have been politically motivated, with national figures that either do not change at all from year to year or take sudden suspicious jumps. But this uncertainty leaves room for both under- and overestimates, and until the sedimentary basins of the entire world (including deep offshore regions) are explored with an intensity matching that of North America and the U.S. sector of the Gulf of Mexico, I see no persuasive reason to prefer the most conservative estimate of...
the ultimately recoverable conventional oil offered by Campbell & Company (no more than 1.8 trillion barrels) rather than substantially higher totals favored by other geologists, including those at the U.S. Geological Survey (their latest estimate is just over 3 trillion barrels). Campbell’s total means that the world has already reached its peak annual production in 2005, while the estimates that are 50–70 percent higher imply the peak sometime after 2020.
Even if the world’s ultimately recoverable oil resources were known with perfection, the global oil production curve could not be determined without knowing future oil demand. We obviously have no such understanding because that demand will be shaped, as in the past, by unpredictable technical advances (who would have predicted in 1930 the new huge market for kerosene that was created by commercial jets by 1960, or in 1970 that the performance of an average U.S. car would double by 1985?) and by shifting prices. As Morris Adelman, who spent most of his career as a mineral economist at MIT, put it: “finite resources is an empty slogan; only marginal cost matters.”

Steeply rising oil prices would not lead to unchecked bidding for the remaining oil but would accelerate a shift to other energy sources. This lesson was learned painfully by OPEC after oil prices rose to nearly $40/barrel in 1981. It led Sheikh Ahmed Zaki Yamani, the Saudi oil minister from 1962 to 1986, to conclude that high prices will only hasten the day when the organization “will be left staring at untouched fuel reserves” because new efficient techniques “will have cut deep into demand for transport fuels” and much of Middle Eastern oil “will stay in the ground forever.” And yet, as already noted, price feedbacks are inexplicably missing from all accounts of coming oil depletion and its supposedly catastrophic consequences. Instead, there is a risible assumption accounts of coming oil depletion and its supposedly catastrophic consequences. Instead, there is a risible assumption that rising prices do trigger powerful adjustments. Between 1973 and 1985 the U.S. Corporate Average Fuel Economy standard was doubled to 27.5 miles per gallon, but further improvements were not pursued largely because of falling oil prices: a mere resumption of that rate of improvement (technically easy to do) would have us averaging 40 mpg by 2015. A more aggressive adoption of hybrids could bring the rate to 50 mpg, more than halving the current U.S. need for automotive fuel and sending oil prices into a tailspin.

And although oil prices are still relatively low (when adjusted for inflation and lower oil-intensity of economies, even $70/barrel is at least 35–40 percent below the 1981 peak!), their recent rise has already reinvigorated the quest for tapping the massive reserves of non-conventional oil. Commercial recovery of oil sands is already rewarding and there are encouraging prospects for further advances with lowered energy cost of production: boundaries between conventional and non-conventional reserves are dissolving. Moreover, global reserves of conventional natural gases contain about as much energy as does conventional crude oil (and major discoveries await), but current gas extraction is equivalent to less than two-thirds of oil output and a truly worldwide market for gas is only now emerging as liquefied natural gas deliveries are converting the previously “stranded” reserves into a massively traded global commodity.

Technical advances—ranging from conversion of gas to liquids to increasing recoveries of coalbed methane and, perhaps already within two or three decades, to the first extraction of methane from hydrates—will gradually supply more gas. And beyond nonconventional oil and a variety of natural gases lie the challenging opportunities of harnessing renewable energy flows, above all by more efficient photovoltaics and even better wind turbines, and introducing smarter and inherently safe ways of nuclear fission. As with all energy transitions, it will take decades rather than years to bring them into the supply mainstream but potential rewards will be immense. And keep in mind that judging their eventual contributions by today’s performances may be akin to judging today’s computer or aircraft performance by the standards of 1950.

When seen from broader resource, technical, and historical perspectives, the recent obsession with an imminent peak of oil extraction has all the marks of a catastrophist apocalyptic cult. Realities are different. Conventional oil resources may be substantially larger than the lowest estimates of peak-oil catastrophists. Even so, it is highly probable that their annual global extraction will peak within the next two decades and it is inevitable that conventional oil will become relatively a less important part of the world’s primary energy supply. But this spells no imminent end of the oil era as very large volumes of the fuel, both from traditional and non-conventional sources, will remain on the world market during the first half of the 21st century. As oil becomes dearer we will use it more selectively and more efficiently, and we will intensify a shift that has already begun: a new global energy transition, from oil to natural gas and to both renewable and nuclear alternatives. As result, there is nothing inevitable about any particular date of peak of global oil extraction. More fundamentally, there is no reason to see an eventual decline of oil’s share in the global energy supply as a marker of civilizational demise.

Energy transitions—from biomass to coal, from coal to oil, from oil to natural gas, from direct use of fuels to electricity—have stimulated technical advances and driven our inventiveness. Inevitably, they bring enormous challenges for both producers and consumers, necessitate the scrapping or reorganization of extensive infrastructures, are costly and protracted, and cause major socioeconomic dislocations. But they have created more productive and richer economies, and modern societies will not collapse just because we face yet another of these grand transformations. Unless we believe, preposterously, that human inventiveness and adaptability will cease the year the world reaches the peak annual output of conventional crude oil, we should see that milestone (whenever it comes) as a challenging opportunity rather than as a reason for cult-like worries and paralyzing concerns.

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