

Chapter 2

Peak Oil

At the start of the new millennium, the expression “Peak Oil” was unknown. Nevertheless, a discussion about when the world’s rate of oil production would reach its maximum had already begun when the geologist M. King Hubbert presented his model for future oil production in the United States in the 1950s. At that time, Hubbert worked for the Shell Company and his model was discussed for the first time at a conference organized by the American Petroleum Institute (API) from the 7th to the 9th of March 1956 at the Plaza Hotel in San Antonio, Texas.

Hubbert’s written conference presentation, *Nuclear Energy and the Fossil Fuels*, was catalogued in June 1956 at the Shell Development Company, Exploration and Production Research Division, Houston, Texas, as “Publication No. 95” [1]. Early in 1957, the API published their 1956 issue of *Production Practice*, thus making the Hubbert model available to all API members.

Half a year before his death, in the spring of 1989, Hubbert described how, on the day that he was to deliver his lecture in San Antonio, Shell tried to get him to tone down his assertion of an approaching production maximum in the United States, but he refused [2]. He also related that, for several years after his presentation, Shell held internal courses for its personnel, and that he presented his model on these occasions. This means that the issue that today goes under the name of “Peak Oil” is something that Shell has known about for more than 50 years. The fact that the API published “The Hubbert Model” in 1957 means that other oil companies have had access to the same information as Shell from that publication date. The question then is why they have swept their discussion of Peak Oil under the rug and have not discussed it more publicly (Fig. 2.1).

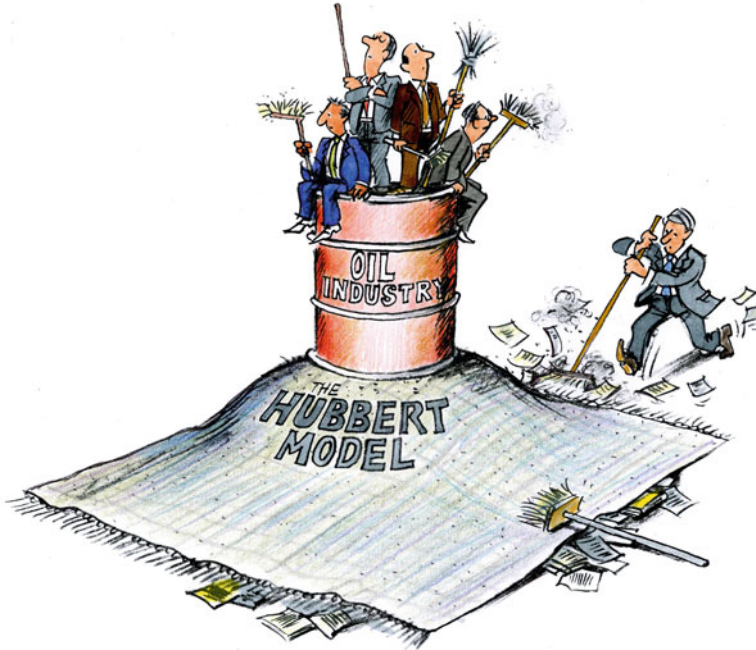


Fig. 2.1 The fact that API published the Hubbert model in 1957 means that Shell and other oil companies since then have had access to the information that oil production will peak. The question is why they have swept their discussion of Peak Oil under the rug and not discussed it publicly

When Hubbert developed his model, it was not the rate of oil production that was of concern but, rather, reported oil discoveries. A review showed that discoveries of oil in the United States' Lower-48 (the 48 states south of Canada), reached a maximum during the 1930s and that the trend was downward in 1955. We know that oil is a finite resource formed under unusual conditions millions of years ago. Therefore, the year when humanity discovered the first barrel of oil will certainly be followed by a year when we discover the last. This discovery history can be approximated by a curve that has a maximum (a peak) when half of the oil resources have been found. The determining factor for the curve's form is the total amount of oil that can be found. Based on the estimates available in 1956, Hubbert used limiting values of 150 and 200 billion barrels of oil for the United States' Lower-48. He further assumed that the production rate curve would have the same form as the discovery curve and constrained the curve to fit the production data up to 1955. Using these assumptions he could predict a maximum rate of oil production sometime between 1965 and 1971. Today, we know that the upper limit was close to reality and that production in the United States' Lower-48 reached its maximum level in 1971.

When Hubbert attempted a similar analysis for the world's oil production, he calculated an estimate of the maximum production rate as occurring during the 1990s. We now know that this was an underestimation. The main reason is that the world's oil production cannot be fitted to a single Hubbert curve because there are many petroleum-producing regions in the world, each of which has its own maximal rate of production, and each must be studied individually. The fact that oil production from the Middle East was restricted for political reasons during the end of the 1970s and beginning of the 1980s is another important factor, and today we should be grateful for all the oil this disruption saved. Some have tried to model oil production rates by combining Hubbert curves for various regions and have, in this way, succeeded in describing broadly the course of history [3]. However, all these curves have a maximum when half of the oil has been produced and detailed analyses of what has really happened in the various regions gives a different picture. Uppsala Global Energy Systems (UGES) at Uppsala University, Sweden, have published detailed studies on this topic that are described later in this book.

Hubbert modeling is a method based in statistics rather than physics. In a Hubbert model, oil production data are fitted to a type of mathematical curve called a logistic curve. Hubbert modeling assumes that the rate of oil production will be maximal when half of the oil reserves have been produced. When the petroleum geologist Colin Campbell began to study future oil production he introduced two fundamental changes. He began fitting curves on a nation-by-nation basis and, more significantly, he based this curve-fitting on "depletion" analysis. According to Campbell, depletion is a measure of what fraction of the oil reserves remaining at the beginning of every year in an oilfield or region can be extracted. In contrast to the Hubbert model, when depletion is measured in this way it also reflects the physical characteristics of an oilfield: the pressure in the field, the porosity of the oil-bearing rock, and the viscosity of the oil. Campbell's method does not assume that the history of the rate of oil production will be symmetrical. The rapidity with which oil production increases before the peak does not need to match the rapidity at which it falls after the peak and the peak itself need not occur when half the oil has been produced.

Some have criticized the Hubbert model for underestimating the rate of production during the latter phase of production from an oilfield or region. However, this does not mean that the Hubbert model has not been useful. To make predictions of future oil production rates, both the Hubbert and Campbell models require estimates of total available oil reserves to be provided. Therefore, the total amount of oil that can be consumed under the two models is the same. The two models differ only in the future production trends that each foresees. When the Hubbert model was developed in the 1950s information on oil discoveries and production profiles was limited

and under those conditions the Hubbert model was very useful for making crude estimates of future production rates. Today we know far more about the history and practice of oil discovery and production for various types of oilfields and regions and this has enabled us to improve our methods for predicting future production rates. We examine these refined methods later but for the moment we simply state that Hubbert and Campbell did pioneering work that led to our current ability to estimate future rates of oil production.

In December 2000 Campbell began to discuss the formation of an organization that would study oil production rate maxima. At first the name proposed was *The Association for the Study of the Oil Peak*, ASOP. During a discussion between Colin Campbell and me in the same month, Campbell suggested that we should invert “Oil Peak” to read instead “Peak Oil,” and so ASOP became ASPO, the acronym still used today. In January 2001 Campbell wrote his first newsletter for ASPO, the Association for the Study of Peak Oil and Gas, and a total of 20 people received that newsletter. In May 2002, at a meeting in Uppsala, ASPO was formally established, and Bruce Stanley from Associated Press (AP) used the expression “Peak Oil” for the first time in the international press [4]. Today (December 2011) a “Peak Oil” search on Google results in over 7,500,000 hits. Campbell has also given us a definition of Peak Oil [5]. “The term Peak Oil refers to the maximum rate of the production of oil in any area under consideration, recognizing that it is a finite natural resource, subject to depletion.”

The future of oil production is decisive for the future of oil companies, and it is to their advantage if the public has limited knowledge of this issue. National bodies, such as the Energy Information Administration (EIA) in the United States, and international bodies, such as the International Energy Agency (IEA) based in Paris, have, for many years, made prognoses of future production. However, only limited information is available on how these prognoses are produced. None of them satisfies the requirements of a scientific publication, and for many there are indications that a political agenda might be influencing the prognoses. The fact that governments around the world use these prognoses to plan our common future—and that Peak Oil will be decisive for that future—means that everyone should possess knowledge of this subject.

At the first-ever *Peak Oil Conference* in Uppsala in 2002 ASPO set the bar for global oil production in 2010 at 85 million barrels per day (Mb/d) [5] (for oil production as defined by BP [6]). Today we know that the oil industry could not clear that height as they only reached 82 Mb/d in 2010 [6]. In Fig. 2.2 this is illustrated by a high jumper knocking off the bar. An analysis of future oil demand published by the IEA in *World Energy Outlook 2010* showed that the world needs more oil production to allow for future economic

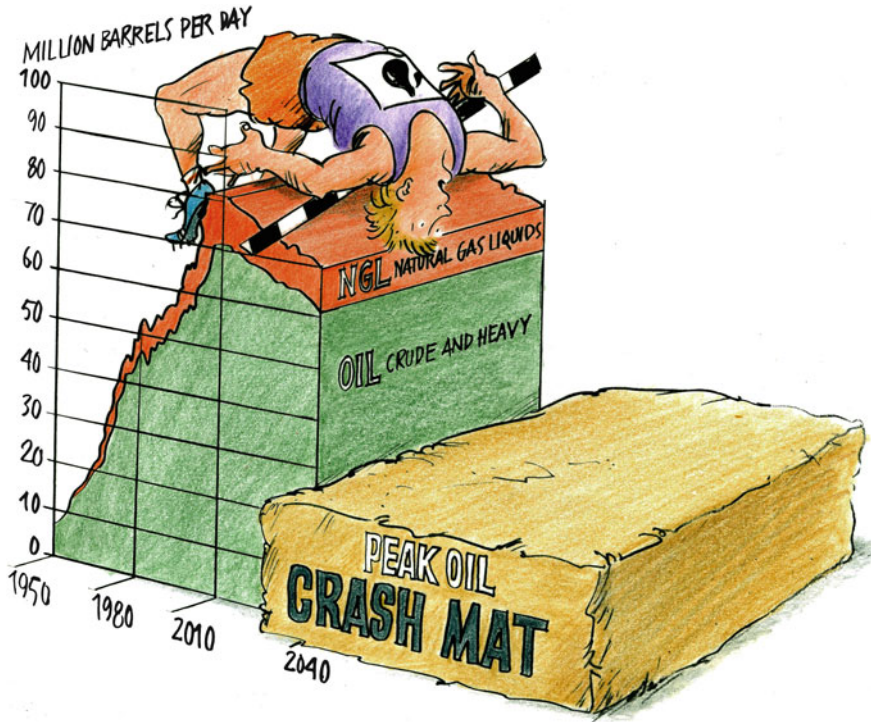


Fig. 2.2 The path up to the peak rate of oil production, Peak Oil, has been long and bumpy with many events along the way that must be explained. The route down begins at the peak and how it will affect us all is of vital importance. Peak Oil will determine our future, and we need to build a substantial “crash mat” of alternative fuel production to cushion us from the fall in conventionally produced oil and the natural gas liquids that are produced in association with conventional oil

growth [7]. This means that there will be a great need for production of alternative fuels in the future as symbolized by the crash mat in Fig. 2.2. We discuss possible alternative fuels later in this book but it is already worth noting that it will be difficult to produce even the volume suggested by the thickness of the crash mat shown. If we fail to provide a crash mat of sufficient thickness the high jumper will suffer a very hard landing!

Peak Oil and Energy Demand

Any geographical area producing oil, no matter how large or small, will experience a moment of maximal oil production that we term Peak Oil. This applies to individual oilfields inasmuch as each oilfield is finite. It must also

apply to any oil-producing region made up of these oilfields. Our finite world is a collection of oil-producing regions so it too must reach a point of maximal oil production, Peak Oil, before the rate of global production inevitably declines.

Discussions of global oil production concern only those nations that possess oilfields and produce oil but discussions of oil supply and consumption concern every nation. Today there is not a nation on Earth that does not use oil and so Peak Oil will affect us all. Peak Oil is only one aspect of global energy use. Therefore, before we discuss Peak Oil in detail in this book we must look at the world's use of oil relative to other energy sources.

When the IEA [7] and BP [6] discuss our sources of energy they categorize them in the following way.

- Fossil energy: coal, oil, and natural gas
- Nuclear energy
- Renewable energy: hydro, wind, solar, biomass, and other sources

Our use of energy over the past four decades is shown in Fig. 2.3. It is obvious that fossil fuels dominate our energy supply [6]. Indeed, all the nuclear and renewable energy combined is still less than 60% of the energy we derive from the least-used fossil fuel, natural gas. Figure 2.3 also shows that we used less energy in total in 2009 (a year of economic recession) than we did in 2008. However, in 2010 total energy use returned to record levels [6]. A closer look at oil production in the past decade shows that this leveled off since 2005 and demand (and so price) continued to rise. In other words, since 2005 our use of oil has been limited by production, not demand. The crucial question now is what will happen to oil production during the coming 25 years. In the prognoses presented by the IEA it sees the rate of oil production continuing to rise until 2035 but in *Peeking at Peak Oil* we show that this is not possible.

Activity requires energy and so increased economic activity (economic growth) requires an increased rate of energy use. Historically, increased use of oil correlates best with increased economic activity. (This is discussed in the section “[The Economy and Peak Oil](#)”, Chap. 19.) All nations use oil so the economy of every nation, and the world economy as a whole, will be affected by Peak Oil. If economic growth and increased oil use go hand in hand then so too must increased carbon dioxide production from burning oil and other fossil fuels. Climate researchers and politicians tell us that we must halve our fossil fuel use by 2050, so from that point of view Peak Oil should be their (and our) best friend. However, to economists, the concept of Peak Oil (and finite resources in general) is like a red rag to a bull. Many economists dismiss Peak Oil on theoretical grounds that have nothing to do with physical reality and the laws of nature. Unfortunately, our politicians

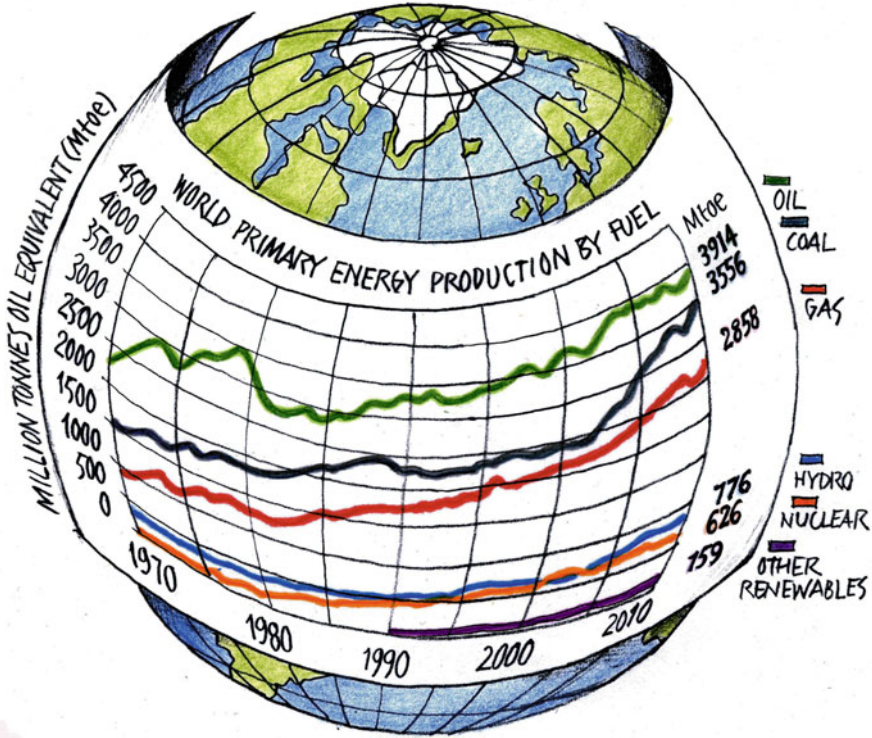


Fig. 2.3 The history of world energy production from 1970 to 2010 showing the contributions to the primary energy supply made by different energy sources. The numbers for “Other Renewables” are based on gross generation from wind, geothermal, solar, biomass, and waste [6]. To allow comparison of these different sources of energy to oil, the energy supplied by each is reported in terms of the heat it can provide (i.e., as thermal equivalence [8]) and is expressed in multiples of the energy in one million tonnes of oil (US: metric tons), that is, Mtoe (US: mt), million tonnes of oil equivalent

have listened to those economists and not the scientists who have been warning about Peak Oil for many years.

To maintain our current economy, a decline in oil use must be countered by an expansion in the use of renewable and/or nuclear energy. Wind and solar energy are popular with the general public and their use is growing dramatically. However, the contribution of wind and solar energy to total world energy use is still only minuscule. These energy sources produce mainly electricity. Most of the world’s electricity is generated using coal and natural gas, so increased use of solar and wind energy will replace those fossil fuels but not oil.

Transport is that sector of the global economy requiring the most oil and Peak Oil will affect it severely. Local transport might use electricity stored in batteries but for transport over long distances liquid fuel is currently essential. Ethanol and biodiesel are liquid biofuels that can be used instead of oil but our analysis in this book shows that their potential to replace oil use is only marginal. Coal and natural gas might also be used to fuel transport so we examine their possible contribution.

The use of oil is deeply integrated into our global energy system so it is essential that we all become aware of the changes our society will need to make to cope with Peak Oil.

What Is Reported as Oil?

The standard unit for measuring volume is the liter (L) but when measuring oil volumes these are described in barrels. One barrel equals 159 L. The rate of production or consumption of oil can be stated as per day (commonly as millions of barrels per day, Mb/d) or per year (commonly as billions of barrels, or gigabarrels, per year, Gb/year, or per annum, Gb/a). Crude oil can vary widely in various qualities such as density, sulphur content, and so on. This is discussed in Chap. 10. Recently, various agencies have also begun to count other chemicals such as ethanol as part of the world's "oil" supply. However, changing the definition of what constitutes oil in this way can complicate comparisons of oil production and consumption between different eras.

In this book we use information primarily from the International Energy Agency, the US Energy Information Administration, and the *BP Statistical Review of World Energy*. The IEA usually discusses the oil the world needs, "demand," and what oil is available to meet that need, "supply." In their *Oil Market Report of March 2011* under the heading "World Oil Supply" they state that 87.4 Mb/d of supply existed for 2010 [9]. This volume includes 1.8 Mb/d of ethanol, 2.3 Mb/d of "processing gains" (which are increases in volume that can occur as oil passes through a refinery), and 0.2 Mb/d CTL (coal-to-liquid) and GTL (gas-to-liquid). From this we can calculate that the actual production of all varieties of oil is only 83.1 Mb/d.

Like the IEA, the EIA also includes processing gains when describing the oil supply but it does not include ethanol [10]. The *BP Statistical Review of World Energy* describes both production and consumption of oil [6]. For 2010 BP saw oil production as 82.1 Mb/d. In this they included crude oil, oil from oil shale, oil from oil sands, and natural gas liquids (NGL) that are produced in association with natural gas production. A barrel of NGL

contains significantly less energy than a barrel of crude oil. This can lead to confusion if the NGL fraction of the “oil” supply is reported in simple barrels (as practiced by the IEA) rather than as barrel of oil equivalents (boe, as practiced by the EIA). Reported available volumes of liquid fuels can also include synthetic oil produced using coal or natural gas.

In this book we focus most of our attention on how much oil exists in oilfields and how much can be produced. When we discuss production of oil, as we do in Fig. 2.2, then we use the definition of this given by BP. For 2010 the oil produced (as defined by BP) was 82.1 Mb/d or 30.0 Gb/year. The most important component of oil production is conventional crude oil and in 2010 this represented 85% of total oil production.

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