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# The peak of oil production—Timings and market recognition

Pedro de Almeida [a,*], Pedro D. Silva [b]

[a] Computer Science Department, University of Beira Interior, Covilhã, Portugal
[b] Electromechanical Department, University of Beira Interior, Covilhã, Portugal

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ABSTRACT

Energy is essential for present societies. In particular, transportation systems depend on petroleum-based fuels. That world oil production is set to pass a peak is now a reasonably accepted concept, although its date is far from consensual. In this work, we analyze the true expectations of the oil market participants about the future availability of this fundamental energy source. We study the evolution through time of the curves of crude oil futures prices, and we conclude that the market participants, among them the crude oil producers, already expect a near-term peak of oil production. This agrees with many technical predictions for the date of peak production, including our own, that point to peak dates around the end of the present decade. If this scenario is confirmed, it can cause serious social and economical problems because societies will have little time to perform the necessary adjustments.



## 1. Introduction

Energy is the lifeblood of present human societies. Without commercial energy (e.g. electricity, natural gas, crude oil and its refined products, coal, and biomass energy products that enter formal commercial circuits) societies as we know them would crumble. In particular, fossil fuels are essential for electricity generation and also to propel modern transport systems. However, in the last few years serious concerns about the future availability of those non-renewable fuels have been brought to public discussion. In particular, the production of crude oil seems unsustainable in a relatively short time frame, and even if the present levels of production can still be somewhat increased in the next few years, that increase will probably be insufficient to match the rapidly growing consumption in countries like China, India, Iran, or Saudi Arabia. At present, the growing tightness between world production and demand has already caused a significant rise in oil prices, seriously affecting most world economies. These facts, together with growing concern about $CO_2$ emissions, are inducing most countries to increase the production of renewable energies. However, most of the relevant renewable energy production techniques are related to the production of electricity, not liquid fuels, and so their impact in the transport sector is limited.

The most recent statistical data from IEA (2007) indicates that the fossil energy is about 81% of the total commercial energy consumed in the world[1] and about 98% of the energy used in the transport sector. These percentages show that, at present, the combined alternatives to fossil energy represent a relatively small proportion of the total energy consumed, and a negligible proportion of the energy used in the vital transportation sector. The very limited present share of the renewable energies is due to important problems that most of them still face, in terms of economic competitiveness of the present technology. Since these problems still prevent a fast ramp-up of the most promising alternatives, there seems to be no escape from the dependence on liquid fossil fuels for the foreseeable future. However, the production of those fuels (mainly crude oil) is approaching a maximum, and will then begin to decline (Hubbert, 1949; Campbell and Laherrère, 1998; Campbell and Heapes, 2008), a phenomenon termed "Peak Oil" (PO). Although disputed when first presented, the general idea of a future peak of oil production is now well accepted. The time frame for that peak, however, is still under discussion. Although most of authors that study this subject already expects a near-term PO, some of them still maintain that the peak of oil production is so far away in time as to be irrelevant (Jackson, 2006). In addition, several authors are already pointing to concerns about a relatively near-term "peak gas" (Laherrere, 2003a; Simmons, 2007), as well as a somewhat more distant "peak coal" (Hubbert, 1971; Zittel and Schindler, 2007). At present, conventional crude oil is the most important of the fossil fuels and it is all but certain that its depletion process is

[1] The other (non-fossil) sources of energy are nuclear (6.3%), hydro (2.2%), geothermal and solar (0.5%), combustible renewables and waste (10.0%). Electricity is not an energy source as such but depends on the conversion of the previously referenced energy sources.

* Corresponding author. Fax: +351 275319899.
*E-mail address:* palmeida@di.ubi.pt (P. de Almeida).

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more advanced. It should be noted that, when talking about the PO problem, the main concern is not the end of oil as an important energy source, but only the peak of its production (and the resulting reduced availability, price increase, and associated economic and social effects).

At present, the available data covering the world's oil reserves and the production and depletion rates of most of the oil fields are scarce and uncertain. Inevitably, the various approaches to predict a PO date suffer from this limited information and the resulting estimates developed by different experts tend to show a wide scatter. This uncertainty about the PO date diminishes the sense of urgency that the problem should command. In fact, although several important recent studies (e.g., Hirsch et al., 2005) point to the need of urgent mitigation efforts to limit the economic and social impacts of the PO, it seems clear that many world leaders and government officials are badly informed and that almost no country is acting consistently to implement effective mitigation changes.

This pervasive indifference about the PO problem is not just the result of direct ignorance, since it is shared by some individuals and organizations that undoubtedly should be well informed. In fact, mainstream media (e.g., New York Times—see Mouawad, 2007), dedicated information organizations (e.g., IEA and EIA—see IEA, 2006; EIA, 2006), energy consulting firms (e.g., CERA—see Jackson, 2006), and even oil extraction companies (e.g., Exxon—see Tillerson, 2007) and some leaders of countries like Saudi Arabia (Jum'ah, 2007) still try to defend publicly the idea that the PO problem is not very important, or at least that it is not a short-term problem of serious concern. However, these public statements contradict the (growing) majority, among those that study this issue that predicts a relatively near-term PO, and some signal that they may be partially explained by direct marketing concerns.

These lingering public "not-a-problem" opinions from organizations related to the oil industry, and the confusion and misunderstandings they still cause, prompted us to try to derive an innovative approach to evaluate the effective beliefs of the participants in the crude oil markets, among which the oil-producing companies are extremely significant. As such, the objective of this paper is to evaluate the evolution of the beliefs (in terms of acknowledgement of the PO problem) of the petroleum market participants, through the analysis of the evolution in time of the crude oil futures price-curves.

## 2. The peak oil problem

The problem of the peak of oil production (PO) was introduced in Hubbert (1949). Before that, concerns about a quick exhaustion of crude oil were occasionally formulated, but none of them was based on a scientific analysis of the problem.

After that first presentation of the problem, Hubbert, a highly respected oil geologist, went on studying this subject and, in 1956, presented an extremely important paper (Hubbert, 1956), in which he accurately predicted that the date for the peak of oil production for the continental USA would be around 1970. That paper also presented the classical approach to the prediction of the unconstrained production profile for a region (or for the world), explaining that the production should follow a bell-shaped curve. At first, that paper raised significant discussion, since the USA was by then the biggest producer of crude in the world, and its production was increasing without apparent problems—in fact, it had to be limited by Government regulation to prevent the "flooding" of markets. However, the ultimate success of that prediction established Hubbert's methodology. In 1971, Hubbert published a paper in which, within some constraints, he predicted the world conventional crude production would peak around 2000 (Hubbert, 1971). Hubbert's model did not incorporate the artificial limitations to oil production due to political constraints imposed by OPEC in 1973 and 1980. In absence of those occurrences, it can be argued that this 1971 prediction again would seem close to be correct.

Hubbert can rightly be considered the father of the research field concerned with the sustainability of the production of natural resources, and of the PO theory. His prediction technique, based on the fitting of a bell-shaped curve to the historical production and to the ultimately recoverable reserves (URR), remains the most used approach to predict future production of exhaustible natural resources and, in particular, of fossil resources.

Mainly using Hubbert's approach, Campbell and Laherrère presented an extremely influential paper in 1998 (Campbell and Laherrère, 1998), discussing the near-term expected peak of oil production, and predicting it to occur "before 2010". This paper influenced the "modern" discussion of the PO problem, and its global impact, leading the authors to create the ASPO,[2] probably the first and presently the most relevant international organization dedicated to the study of the PO problem.

In terms of direct indicators to a relatively near-term PO, one of the most evident is the fact that in the last few decades the discovery of new oil fields has been lagging the extraction of oil from previously discovered fields. In the last few years, this tendency has become much worse, so that today new fields being discovered represent only about a fourth of the oil being extracted (ASPO, 2007). Another indicator pointing to a short-term PO is the strong reduction in the OPEC spare production capacity, clearly illustrated in Fig. 1. The non-OPEC oil-producing countries have been producing at almost full capacity since 1990. The evolution of oil prices through time, illustrated in Fig. 2, is itself a further indicator of a fundamental tightening of the production/demand balance and, in fact, for many observers it is the most ominous of them.

In this context, the depletion of the presently producing oil fields constitutes a growing problem. Depletion rates typically range between 2% and 4% in "well behaved" big onshore oil fields and up to 18% in some deep-water fields (Jackson and Eastwood, 2007). With 86 Mb of daily production, it is easy to understand that a permanent effort is needed just to maintain the present level of production. This effort includes the opening of new oil wells in presently producing fields, increased water injection, the use recent technologies like 4D analysis and horizontal and multilateral wells, and the use of several techniques of enhanced oil recovery (such as nitrogen, $CO_2$, or steam injection). Even so, the discovery of new oil fields is necessary to compensate for the reduction of the production rates of the present oil fields. The depletion problem is being compounded by the recent peak of production of some the biggest oil fields in the world (such as Cantarell and Burgan), and by the growing proportion of production from deep-sea oil fields that tend to be depleted extremely fast.

These various indicators that point to a near peak of world oil production also illustrate the production problems in individual countries. Many countries, among them some important producers like the USA and Indonesia, had their individual peaks years ago, and go on losing production in spite of the technologic advances in exploration and production and of the increased drilling efforts brought about by the present "high" crude oil prices. Additionally, in the last few years other important producing countries like Venezuela, Nigeria, Norway, and Mexico

[2] Association for the Study of Peak Oil and gas (ASPO) (http://www.peakoil.net/).