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An oil production forecast for China considering economic limits

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ABSTRACT

In recent years, it has become apparent that oil prices may not rise endlessly. Unconventional oil is likely to be especially affected by low prices because it tends to be high-priced to extract. To estimate the impact prices might have on future Chinese oil production, we develop a model in which only future unconventional oil production is affected by price. We analyze three price scenarios: Stays Low, Best Estimate, and Ever-Rising Prices. In these scenarios, remaining Ultimate Recoverable Resources (URR) are estimated to be 10%, 50%, and 90% of remaining Technically Recoverable Resources, respectively. Since oil price can be expected to affect the shape of the extraction curve, we spread estimated URR to year using models that do not assume that future production will ultimately produce a symmetric Hubbert-type curve (Multi-Cycle Generalized Weng Model and Stochastic Resource-Constrained Growth Model). In the Best Estimate Scenario, China's oil production is expected to reach a maximum of 226.79 million tons in 2020. In the Ever-Rising Prices Scenario, China's maximum oil production occurs in 2023. In the Stays Low Scenario, maximum production has already been reached.

1. Introduction

China is the world's largest oil consumer and the world's fourth largest oil producer [1]. One issue that has arisen, especially since mid-2014, is the issue of low prices and their potential impact on China's future production. The goal of this paper is to provide a range of estimates of future oil production under selected price scenarios, to better understand the impact that low oil prices might have on future production. We also discuss some reasons why oil prices should not be expected to continue to rise endlessly.

In order to accomplish this, we analyze conventional and unconventional oil separately, since unconventional oil tends to be high-priced to extract, and thus is likely to be affected by low oil prices to a greater extent than conventional oil. Furthermore, conventional oil tends to be extracted first because it is cheapest and easiest to extract. As a result, the oil resources that remain contain a disproportionate share of unconventional oil.

A number of other researchers have developed estimates of China's future oil production [2–4]. None has considered the conventional/unconventional split and the impact of price on these estimates.

2. Oil prices and expected quantity extracted

2.1. How economic limits affect oil extraction

Often estimates of future oil production are based on estimates of technically recoverable resources (TRR), given today's technology. In some cases, particularly climate analyses, estimates are based on Oil in Place (OIP), assuming that technology will gradually improve, allowing an increasing proportion of the OIP to be extracted.

There is an economic question that needs to be considered as well. Often, the assumption is made that oil prices will keep rising, allowing all of the oil to be extracted that technology permits. We know that the cost of producing oil will keep rising because we extract the cheapest to produce oil first, leaving the more expensive-to-produce oil for later. The question, which many have never considered, is, “Will the p rice which the marketplace offers for oil continue to rise as quickly as the cost of producing oil? Or will the price of oil lag behind, and production be cut off as a result of the lagging price?”

The IEA in its Figure 1.4 of World Energy Outlook 2015 (WEO 2015) assumes that oil prices can rise to $300 per barrel by 2100 [5]. Even this price may not act to extract all TRR, since some oil may be in very small deposits or ones that are very deep and away from needed resources. Some TRR is located under cities, necessitating

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moving large numbers of people to access the resource. Such a move would be very expensive, quite possibly more than $300 per barrel. Fresh water is often needed for extraction, but is not available locally. In theory, it could be trucked long distances, or it could be obtained by desalinating seawater and installing pipelines so that this desalinated water could be pumped uphill to where it is needed. While technically feasible, the cost is likely to be prohibitive.

The world recently has struggled for roughly 24 months with low oil prices. A similar problem happened in the second half of 2008 and in 2009. We can no longer simply assume that prices will rise with rising cost of extraction. If nothing else, if oil prices rise to $300 per barrel or higher, substitutes such as coal to liquids will become competitive, and thus can be expected to hold oil prices down.

Physicist François Roddier has given a thermodynamic explanation of the difficulty we are encountering. Roddier describes all of human society as a dissipative structure that self-organizes to maximize its use of energy [6,7]. With this understanding of the role of energy (not just oil), the growing use of energy is essential to the growth of the economy; a reduction in the growth in energy consumption can be expected to lead to slowing economic growth. This view is supported by the fact that there is a high correlation between world Gross Domestic Product (GDP) and world energy consumption since 1975, as illustrated in Fig. 1. In fact, there seems to be a strong relationship between energy consumption and economic growth, going back as far as 1820 (Fig. 2). The fact that GDP is growing more rapidly than the use of energy on Fig. 2 would suggest that other factors, such as improved technology and energy efficiency, may also be contributing to GDP growth.

The rising cost of producing energy products (including oil) is a sign that diminishing returns are affecting the system. Companies that had previously extracted conventional oil at relatively low cost are forced to move on to higher-cost unconventional oil. As production costs rise more quickly than the inflation rate, more resources are transferred into the energy-production sector of the economy, and away from the production of other goods and services. If this pattern continues, the growth of the economy can be expected to slow. With slowing economic growth, demand for energy products, including oil, seems likely to fall. Instead of ever-rising prices, we may encounter recession and low or falling oil prices, such as we have been seeing recently. These low prices may eventually lead to the end of oil production.

2.2. Selection of oil price scenarios

Clearly, different observers have different ideas regarding how oil prices may change in the future. We have chosen to look at three different oil price scenarios. In our Best Estimate Scenario, we assume that approximately 50% of remaining TRR[1] for unconventional oil will ultimately be recoverable. The way we might expect this to happen is if future oil prices are somewhat in the range of IEA's "Low Price Scenario" and "450 Scenario" in IEA's WEO 2015 [5], as shown on Fig. 3. In this scenario, a typical price between now and 2100 might be in the $100 to $125 per barrel range.

Our second scenario is called the "Ever-Rising Prices Scenario." In this scenario, we expect that 90% of remaining TRR for oil will be recovered. This scenario is expected to be in the range of IEA's "Current Policies Scenario" shown on Fig. 3. In this scenario, prices will keep rising as needed to keep up with higher extraction costs. Thus, prices may rise as high as $270 or $300 per barrel by 2100. Over time the view of TRR may rise, because high prices encourage the development of new resources and new techniques.

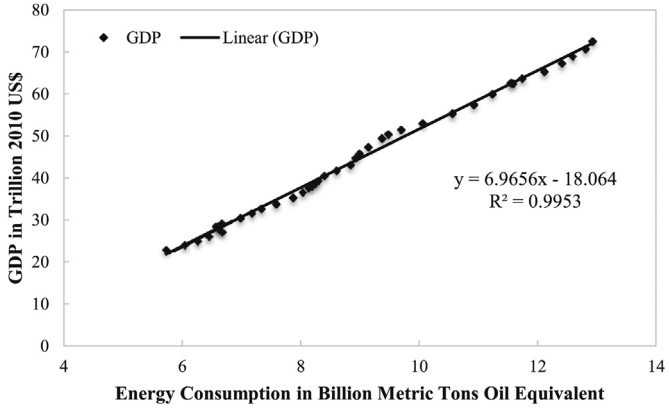

Fig. 1. World GDP compared to Energy Consumption 1975 to 2014. Data sources: [1,8].

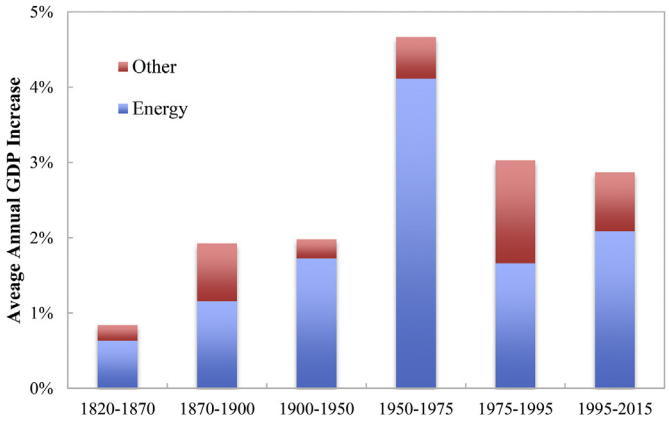

Fig. 2. Average GDP growth rate, divided between increases in energy consumption and other influences, such as technology and efficiency improvements. Data sources: [1,8–10].

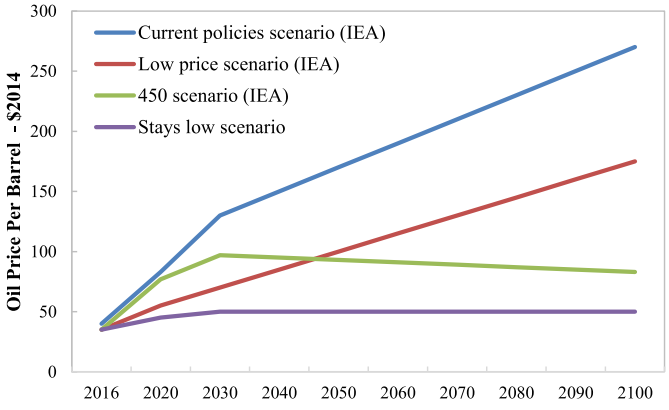

Fig. 3. Oil price scenarios of interest. The first three scenarios listed are based on scenarios from IEA WEO 2015 [5]. Values for dates through 2040 are as given by IEA. Values after 2040 are estimated assuming that prices will follow the same linear change pattern after 2040 as IEA indicates will occur between 2030 and 2040. The Stays Low Scenario is a creation of the authors. It assumes that oil prices will remain at or below $50 per barrel indefinitely.

[1] Definitions to TRR diverge among different agencies. In order to make it clear in this paper, we use "TRR" to indicate total amount of technically recoverable resources that exist underground before the production starts, while we use "remaining TRR" to indicate resources yet to be extracted technically. The same explanation applies to "URR" and "remaining URR" used in this paper.