

# The last oil?

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## **How serious are warnings of oil shortage and price hikes, and do we have hedging strategies within reach?**

Oil is a depletable resource, and findings of oil in new fields have declined since about 1965 (Fig. 1). On the other hand, enhanced recovery techniques using gas injection have been developed, increasing in many cases the extraction of the oil in place (within geological formations) from under 40% to about 50%. Further improvement of extraction techniques, e.g. using *in situ* combustion, high-pressure chemistry or bacteria to free more oil from rock pores, could in some cases increase recovery to 60 or 70%, albeit at a higher cost (3). During the past 50 years, oil exploration has taken place in all corners of the world, from low to high latitudes, and the chance of large unexpected finds violating the trend shown in Fig. 1 must be judged as tiny, although the possibility cannot be excluded.

In the light of these considerations it is not difficult to formulate models for possible levels of oil production in the near future, and compare them to expectations for oil demand. Figure 2 summarises a range of such models for oil production and the associated consumer price, including unpredictable fluctuations. Until the present time, the top part of Fig. 2 shows a historic oil production that essentially follows demand. After the oil crises in 1973 and 1979 and the associated price increases, demand changed from the exponential growth of the previous period to becoming nearly constant (while economic growth in most parts of the world continued nearly unchanged after a year's delay). This was chiefly due to more efficient use of oil and to substitution with other fuels, which was possible in industry and for power supply, but not in the transportation sector.

The expectations for the next decades is renewed growth in oil products used for transportation, due to the rapidly growing car ownership and air travel in countries with expanding economies, such as China (4). This growth in oil use makes the expected reserves of Fig. 1, exploited with use of the mentioned enhanced recovery techniques, last to about 2040, and the geographical distribution of oil resources is such that OPEC production will have to rise by at least 60% during the period, while production in Europe and the US declines (5). The uncertainty in estimating the duration of reserves at different assumptions regarding price and improved extraction does not move the "trouble point" more than a few decades, but even this is quite important for the effort of developing alternatives to oil. The IEA report (4) does not expect oil to become economically unattractive before 1930, while the report presented at the Center for Strategic and International Studies in Washington says supply problems (i.e. demand surpassing production) may arise as early as 2015, depending on assumed levels of economic growth around the world (5). An oil industry report has also warned of a supply gap around 2020 (6).

All these reports recognise that there will be additional costs associated with raising oil production by 60%. The consumer price may continue to fluctuate wildly, the way it has over the past 20 years (see lower part of Fig. 2), but ultimately the supply problem can only lead to higher prices, as long as no backstop substitution fuel has been identified. Candidates such as liquefaction of coal or biomass into oil-substituting fuels currently have price tags of the order of 100 US\$/bbl of oil equivalent. If substitution prices become lower, a softer transition with partial substitution of oil over a longer period of time may emerge, as indicated in Fig. 2.

The higher the use of oil, the more abrupt will the decline be, and the more likely panic pricing. In any case, all these estimates ignore the possibility of supply problems due to political instability that could lead to civil warfare in the oil-rich regions, or to regime changes leaving uncertainty about the willingness to continue to let production follow the demands of the oil-importing countries. The geopolitical and supply-security implications of these possibilities are huge. The two reports quoted (4, 5) both recommend energy policies reducing demand and speeding up a transition away from oil dependence. The last 5 years, passenger cars have been on the European market with a fuel economy three times better than the current US average. Inducing more customers to buy such vehicles would stretch the period available for further developing and introducing alternatives, such as hydrogen and fuel cell vehicles estimated to need at least 20 years to make a significant indent in the market (7). Ensuring that already available energy efficiency techniques are implemented will buy resilience.

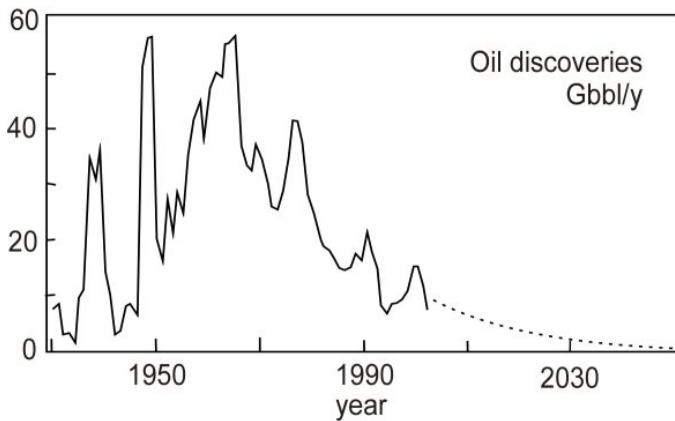


Figure 1. Year-by-year global oil discoveries (solid line) and a model for future finds (dashed line) (1, 2).

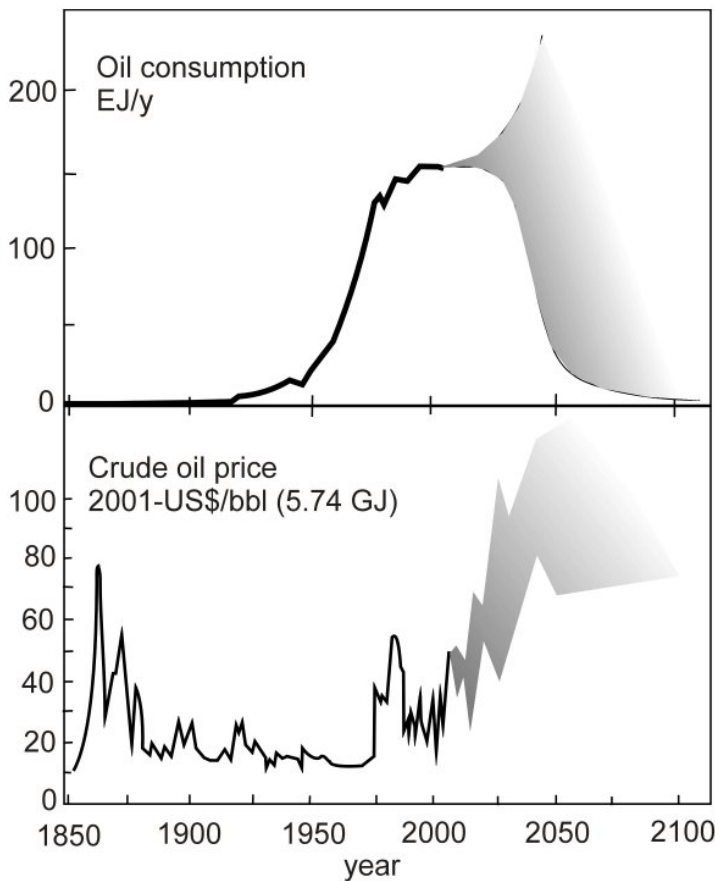


Figure 2. The historical global consumption of oil at top (8) and the historical price levels of crude oil at the bottom (9, 10), supplemented with model estimates of possible future behaviour.

## References and Notes

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