When Will Oil Peak?

Sometime soon petroleum production will begin declining. Can we be prepared?

World oil production peaking will require physical mitigation if we are to avoid severe, long-lasting, worldwide economic damage. In the following, we identify available options for oil peaking mitigation, and we estimate the time required for effective implementation. Our approach is approximate and transparent to facilitate understanding.

As is widely appreciated, projecting future world oil production is an extremely complex problem. Experts have used various data, estimates, and formalisms to develop forecasts for when world oil production peaking might occur. We take no position on the timing, only that it is certain to occur.

Consuming Capital Stock

The transition away from petroleum-derived liquid fuels will be paced by a number of factors, the massive size of the transportation capital stock being one of the most important. Based on historical trends, oil-consuming capital stock has been replaced in the U.S. over periods ranging from 15 to 50 years. Table 1 lists the size, median lifetimes, and replacement costs for four categories of the transportation capital stock. The largest remaining oil-consuming capital stock resides in the industrial sector, where oil consumption is very diverse.

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Roughly two-thirds of U.S. oil consumption is used in the U.S. transportation sector. The fraction is roughly 55 percent elsewhere in the world, but the difference is narrowing as world economic development is rapidly expanding transportation.

Supply Disruptions

There have been over a dozen global oil supply disruptions over the past half-century. They ranged in duration from one to 44 months, and supply shortfalls varied from roughly one percent to nearly 14 percent of world demand. The most traumatic disruption occurred in 1973-74 and lead to greatly increased oil prices and significant economic damage worldwide. The second most traumatic disruption in 1979-80 was neither the longest nor involved the largest supply shortfall. The aftermath of those two events offer insights into what might occur when world oil production peaks.

In 1973-74 and 1979-80, higher oil prices resulted in increased costs for the production of goods and services, inflation, unemployment, and recession. Tax revenues declined and budget deficits increased, driving up interest rates. While oil price spikes may not be necessary to cause recessions, they have proven to be sufficient.

Estimates of the damage to OECD countries caused by past oil price disruptions vary substantially, but the effects were significant. The loss suffered by the OECD countries in the 1974-75 recession was estimated to be $350 billion (current dollars) / $1.1 trillion 2003 dollars. The loss resulting from the 1979 oil disruption was about three percent of GDP ($350 billion in current dollars) in 1980 rising to 4.25 percent ($570 billion) in 1981. Developing countries suffer more from oil price increases because they are generally more dependent on oil.

Mitigation of Oil Peaking

To explore what actions might be taken to mitigate the impacts of world oil production peaking, we analyzed three mitigation scenarios:

- The first assumes that action is initiated when oil peaking occurs;
- The second assumes that action is initiated 10 years before peaking; and
- The third assumes action is initiated 20 years before peaking.

Our analysis was centered on the date for oil peaking, which was remains an unknown. The scale of the problem is worldwide, because oil markets are worldwide.

Our focus was on large-scale, physical mitigation—activities that have potential both to substantially reduce the consumption of conventional oil (improved fuel efficiency) and to increase supply through the production of very large quantities of substitute oil.

Mitigation Strategies

We assumed that initiation of mitigation to be instantaneous and implementation to proceed on a crash program basis. This yielded what we believe to be the most optimistic, limiting case. We considered only technologies that are currently commercial or near commercial today, i.e. technologies that are established as viable. The options that we considered were

- Fuel-efficient transportation,
- Enhanced Oil Recovery (EOR),
- Heavy oil/oil sands,
- Gas-to-Liquids (GTL), and
- Coal-To-Liquids (CTL).

Table 1.
Characteristics of the U.S. Transportation Fleets

Fleet	Size	Median Lifetime (Years)	Estimated Cost to Replace Half of the Fleet (2003 $)
Automobiles	130 million	17	$1.3 trillion
Light trucks, including vans, SUVs,pickups	80 million	16	$1 trillion
Heavy Trucks, Including buses, highway, off-highway	7 million	18	$1.5 trillion
Aircraft	8,500	22	$250 billion

A dramatic increase in the efficiency of petroleum-based fuel equipment is clearly possible. In recent years, fuel economy for automobiles has not been a high national priority in the U.S. and some other parts of the world. Nevertheless, hybrid engine technology has been phasing into the automobile and truck markets. In a sustained worldwide oil emergency, hybrid technology could be massively implemented for new vehicle applications, offering significant fuel economy improvements for automobiles and light-medium trucks.

Rationales for our fuels production options were as follows:

- Enhanced Oil Recovery could be applied on a massive scale worldwide.
- Heavy oil / Oil sands is currently commercial in Canada and Venezuela and has considerable upside potential.
- Gas-To-Liquids is commercially applicable for remote natural gas.
- Coal liquefaction is a well-developed, near-commercial technology

The most widely applicable EOR process involves the injection of CO_2 into conventional oil reservoirs to dissolve and move residual oil. Because EOR processes require extensive planning, large capital expenditures, and procurement of very large volumes of CO_2, world scale EOR will not happen quickly and will likely be paced by the availability of massive volumes of CO_2, since the world's largest oil reservoirs are generally remote from large CO_2 sources.

Significant heavy oil production currently exists in Canada and Venezuela. While their total resource is estimated to be 3-4 trillion barrels, the recoverable oil reserves are estimated to be roughly 600 billion barrels, which could support a massive expansion in production.

In the case of Canadian oil sands, a number of factors would challenge a crash program expansion, such as the need for massive supplies of auxiliary energy, huge land and water requirements, environmental management, and the harsh climate in the region. In the case of Venezuela, large amounts of supplemental energy, inherently low well productivity and other factors will likely pose significant challenges.

Crash Programs

Recent statements by the World Energy Council (WEC) guided our estimates for what might be achieved on a crash basis. Under the business-as-usual conditions assumed by the WEC, Venezuela is projected to produce 6 MM bpd by 2030—5.5 MM bpd beyond 2003 production of 0.5 MM bpd. If we assume this level of production is achieved 10 years after initiation of a crash program, rather than the roughly 25 years estimated by WEC, then 5.5 MM bpd of incremental production might be attainable.

In Canada, current plans are for oil sands production of 3 MM bpd of synthetic crude oil (SCO) from which refined fuels can be produced by 2030. This is above current production of 0.6 MM bpd of SCO. If we assume this level of production is achieved 10 years after initiation of a crash program, rather than the roughly 25 years targeted by the Canadians, then roughly 2.5 MM bpd of incremental production might be possible. For purposes of our rough estimates, we assume no upper limit on production for either country for the time periods considered.

Gas-To-Liquids is a rapidly expanding enterprise, whose crash program expansion would be partially muted by competition for remote gas for LNG. Coal liquefaction has been commercialized by SASOL and a number of other gasifier systems are also potentially ready.

Over 45 percent of world oil consumption is for non-transportation uses. Fuel switching away from non-transportation uses is certain to occur as a result of oil peaking. The potential for fuel switching is important and was beyond the scope of this analysis. Under any conditions, to have meaningful world-scale impact, alternate energy facilities would have to be built on a massive scale to significantly reduce world oil consumption. That would require decade time scales in line with the options that we considered.

We excluded a number of other energy options for various reasons. While the U.S. has a huge resource of shale oil that could be processed into substitute liquid fuels, the needed technology is not now ready for deployment. Biomass options capable of producing liquid fuels were also excluded. Ethanol from biomass is currently utilized in the transportation market, not because it is commercially competitive, but because it is mandated and highly subsidized. Biodiesel fuel is a subject of considerable current interest but it too is not yet commercially viable.

Delayed Wedge Approximations

In order to keep our analysis simple and transparent, we assumed that the introduction of each mitigation technology could be approximated by a "delayed wedge." The delays before initial contribution would be required for the retooling of manufacturing facilities for fuel efficient vehicles or the construction of substitute fuel production facilities.

To approximate world oil production as a function of time, we adopted the pattern for the U.S. Lower 48 states on the basis that Lower 48 oil production represents what actually happened in a very large, complex oil province over the course of decades of modern oil production development.

Using the 50 year U.S. Lower 48 states oil production pattern to approximate what might occur worldwide, we assumed world oil production would peak at 100 MM bpd, higher than the current level of 80+ MM bpd and a round number. Choice of 100 MM bpd is not meant to imply a peaking forecast. Finally, for simplicity, we assumed an imbedded 2 percent increase in world oil demand after peaking, recognizing that price escalation and economic responses will surely alter post peaking demand.

Together, implementation of all of the options would provide roughly 15 MM bpd impact, ten years after simultaneous crash program initiation. Roughly 90 percent of mitigation would result from substitute liquid fuel production and roughly ten percent would come from transportation fuel efficiency improvements, because of low transportation capital stock turnover rates.

Briefly, if mitigation is not started until peaking occurs, over of decade or oil shortages and economic hardship will ensue. Initiation of mitigation 10 years before peaking still results in supply shortfalls, albeit not as severe. Only initiation 20 years before peaking would avoid shortages.

Our results are both approximate and optimistic. The major conclusion from the analysis is that with adequate, timely mitigation, worldwide fuel shortages can be avoided. If mitigation were to be too little or too late, world supply/demand balance will be achieved through massive demand destruction (shortages). Such shortages would translate to prolonged economic hardship similar to the periods following the 1973 and 1979 oil shortages but in the case of world oil peaking, lasting much longer.

Table 2.
Mitigation Wedge Estimates

Technology	Delay until first impact (years)	Impact 10 years after first impact (MM bpd)
Vehicle Efficiency	3	1
Gas-To-Liquids	3	2
Heavy oils / Oil Sands	3	8
Coal Liquids	4	5
Improved Oil Recovery	5	3

Natural Gas Experience

A dramatic example of the risks of over-reliance on oil and gas reserves projections is the evolving North American natural gas situation. Over the past 10 years, natural gas became the fuel of choice for a variety of applications, most notably new electric power generation. Optimistic resource estimates for low-cost, abundant U.S. and Canadian supplies were an underpinning of natural gas attractiveness.

The situation is very different now. As summarized by CERA: "Gas production in the United States (excluding Alaska) now appears to be in permanent decline, and modest gains in Canadian supply will not overcome the US downturn." Similar evaluations have been provided by others.

As is the case for oil, natural gas reserves estimation is subject to large uncertainties. Furthermore, U.S. natural gas experience is another example of the fact that high prices do not a priori lead to dramatically higher greater production. Geology is ultimately the limiting factor, and all too often, geological realities are clearest after the fact.

Concluding Remarks

There is no question that world oil peaking will occur, but the timing is uncertain. Some think it could be soon; our analysis suggests that "soon" is within the next 20 years. Mitigation will require an intense effort over decades. This inescapable conclusion is based on the time required to replace vast numbers of liquid fuel consuming vehicles and the time required to build a substantial number of substitute fuel production facilities. Even crash programs will require more than a decade to yield substantial relief. In the real world, decision-making will be slower. Shortages of trained personnel and equipment manufacturing will limit startup, so meaningful mitigation will almost certainly be delayed beyond what our analysis shows.

Many motor vehicles, aircraft, trains, and ships simply have no ready alternative to liquid fuels. Oft publicized energy alternatives, such as solar, wind, photovoltaics, nuclear power, geothermal, fusion, etc. do not produce liquid fuels, so they cannot impact transportation until major technology shifts are implemented on a significant scale. Oil peaking represents a liquid fuels problem for the transportation sector, not an "energy crisis" in the sense that term has been often used.

Given enough lead-time, the problems are solvable, and otherwise dire consequences can be avoided. How and when these challenges will be seriously addressed and when world oil production peaking actually occurs are yet to be determined.