

## "PEAK OIL" – REALITY OR MYTH?

**Mirela Costianu**

Institution: Doctoral School of Bucharest University of Economic Studies

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**ABSTRACT:** *Oil industry is one of the biggest industries in the whole world, as oil is our most important natural resource. We cannot imagine the society as we know it without oil. Still, specialists say it is possible that, not in a very long term, to have to learn how to live without oil, because the moment known as "Peak Oil" has already passed or is just around the corner. Of course, there are also specialists who say that the world is still "bathing" in oil and we shouldn't worry for that for many years ahead. So, who is right and who is giving the wrong signals? Who should we trust? What are the figures saying? Should we start looking for an alternative as soon as possible or should we relax and wait for the moment when we must start to worry? Is "Peak Oil" only a myth or is it the reality that we are confronting nowadays? The literature and specialist in the domain don't give us too many information, but we can still draw some conclusions from what we know.*

**KEYWORDS:** oil, Peak Oil, energy resources, Hubbert, Hubbert's curve

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### INTRODUCTION

#### Should we worry?

"Study the past if you would define the future" is a famous quote of Confucius (551-479 BC). Sometimes, the only known way to make predictions about the future is to extrapolate the trends. However, we must be aware of the fact that these methods are not accurate and differences between the future reality and our expectations are possible. Oil is not a big business, it is a huge business. Since the first American barrel of oil was extracted in 1859, the global oil sales of 40 trillion dollars (2007\$) during the year 2008 has exceeded ten times the Federal budget of the United States in that year, or, in other words, the money resulting from the oil sales would have been enough to give 55,000 dollars to each man, woman and child in the world. In top 5 in 2008 *Fortune companies*, oil companies have declared 61% of the revenues included in this top.

Even though this industry is one of those that move the life "engine" of the whole world, the decline of oil production is something that international oil companies do not, normally, want to discuss. However, in 2002, Harry J. Longwell, Director and Executive President of ExxonMobil Corporation, published an article in *World Energy* in which he clearly asserted that the production of oil from the oilfields in use will decrease dramatically by 2010 [1]. In a report from February 2004 addressed to the shareholders, *A Report on Energy Trends, Greenhouse Gas Emissions and Alternative Energy*, the same Exxon Mobil company has predicted an alarming future: "In other words, by 2015, we will need to find, develop and produce a volume of new oil and gas that is equal to eight out of every 10 barrels being produced today " [2].

"Peak oil" or "apogee oil" (referred in the literature as "Peak Oil", hereinafter referred to the same) is the point in time when the maximum rate of extraction of petroleum is reached. The basic idea is very simple: since oil is a non-renewable resource, the quantity extracted will be increasingly higher, up to a certain moment, when a peak will be reached (also called the "Hubbert Peak"), following which will begin, inevitably, to decrease. The history of oil extraction follows a mathematical curve, shaped like a bell, called "Hubbert's curve". This law applies not only in the case of oil, but also for many other resources. Oil extraction began at the end of the 19th century. World's interest has increased as people have realized how important this resource is for economy. More and more oil was discovered and the extraction rate increased incessantly. However, after 1964 (which represented a peak year), discoveries of new oil oilfields have begun to be increasingly reduced. This did not happen because searches was abandoned, but for the simple reason that oilfields have become more and more difficult to find - with all the advantage given by the new technologies. It is obvious that, once the discoveries of new deposits are more and more scarce, there will come a time when the amount extracted would decline as well.

Why should we worry? "Peak oil" means a dramatic change. Oil has represented, in the past century, the basic source of economic growth and technological development. Along with this development, the demand for oil has become increasingly higher - and this demand was covered by a continuous increase of the oil extraction. This may no longer be done after "Peak Oil". All these will lead, of course, to the increase in the prices for gasoline and diesel fuel, but this is only an absolutely minor factor. If we consider only the issue of transportation - all products will become more expensive. Food will be the first on the list (let's not forget that agriculture involves a series of operations which are carried out by means of agricultural machinery, which use diesel fuel). Moreover, the petrochemical industry is dependent on oil. "Peak Oil" will therefore affect every aspect of industry which uses energy or oil as a raw material.

Among the economists of the world, the one who is the most knowledgeable about "Peak Oil" and the future of oil production is Fatih Birol, Chief Economist of IEA. In an interview for the French newspaper "Le Monde" in 2007, he actually declared that the peak of oil production is just around the corner. "If Iraqi production does not rise exponentially by 2015, we have a very big problem, even if Saudi Arabia fulfills all its promises. The numbers are very simple, there's no need to be an expert". The entire interview is direct and frank. He also notes that Africa already suffers the most because of higher oil prices, that a decrease in China's development will not lead to a reduction of the demand and explains clearly the peak of oil production and resource depletion. "Within 5 to 10 years, non-OPEC production will reach a peak and begin to decline, as reserves run out. There are new proofs of that fact every day. At the same, we'll see the peak of China's economic growth. The two events will coincide: the explosion of Chinese growth, and the fall in non-OPEC oil production. Will the oil world manage to face that twin shock is an open question". He emphasized even twice in the same interview: the discrepancy between the supply of and demand for oil will increase and he accuses the national governments for their lack of reaction and because they do so little in this regard. Concurrently, he expresses the hope that consuming nations will implement policies that will influence significantly the demand curve. Furthermore, Faith Birol talks also about the depletion of Saudi reserves and resources: "I understand the Saudi government claims 230 billion barrels of reserves, and I have no official reason not to believe these numbers. Nevertheless, Saudi Arabia - as well as other producing countries and oil companies -

should be more transparent in their numbers. Oil is a crucial good for all of us and we have the right to know how much oil, as per international standards, is left" [3]. In 2008, he made a series of comments about the future of oil production in an article published in the *Independent* newspaper, but without mentioning exactly the expression "Peak Oil" [4]. However, his comment sustains the point of view saying that we are facing an imminent maximum of production: "We are on the brink of a new energy order. Over the next few decades, our reserves of oil will start to run out and it is imperative that governments in both producing and consuming nations prepare now for that time. We should not cling to crude down to the last drop – we should leave oil before it leaves us. That means new approaches must be found soon."

However, EIA stated that we cannot have global economic growth without increasing the overall consumption of energy. For example, in 1945, at the end of the Second World War, Sweden was a rather poor country. Nevertheless, in the following years, this state's GDP has grown immensely and by 1970 it has become the third richest country in the world per capita. In the period between 1945 and 1970, the energy consumption of Sweden has increased five times, which corresponds to an increase of 7% per year for 25 years. This energy came mainly from cheap oil imported from the Middle East. Thus, until 1970, Sweden's economy has become the most dependent economy on oil in the world.

"Peak Oil" is misunderstood as being the end of oil. Actually, "Peak Oil" means that the production of oil and its availability will only decrease, will not cease. The biggest problem is then how we will prioritize the use of oil in the future. In some cities, notable being Bristol in Great Britain [5] and Brisbane in Australia [6], have already been made analyses about how "Peak Oil" will affect their future. Today, in many cities in the industrialized countries, municipal centers that have been neglected between the years 1980 and 1990 are renovated and often only rich people can afford to live there. Meanwhile, families with low income often live far away from the outskirts of the city and have to commute long distances in order to go to work. In the USA, before the financial crisis in 2008, it has been noted that these poor families, living in the periphery, were the first to be affected by the high oil prices. Oil price, more than doubled from 2005 until 2008, has "stolen" a huge part from the budget of these families. For them, a way of dealing with this issue was to stop paying their mortgage rates and give their homes to banks. Thus, "Peak Oil" and the financial crisis were in close connection.

Understanding of the oil global supply becomes more complicated by the fact that the large oil companies adopt opposite positions as regards the "Peak Oil" topic. On the one hand, some oil companies announced that the available remained oil is depleted fast. On the other hand, at the same time, the statement that the peak production of oil is not even close was often made. For example, the same Exxon Mobil published in March 2006 a work entitled "Peak Oil?", which argues: "Contrary to the theory, oil production shows no sign of a peak...A peak will not occur this year, next year or for decades to come...With abundant oil resources still available peak production is nowhere in sight."

And yet, there have been predictions regarding the end of oil even since it has become an universal good. Not later than 1916, the US Bureau of Mines declared: "In the exhaustion of its oil lands and with no assured sources of domestic supply in sight, the United States is confronted with a national

crisis of the first magnitude" [7]. A report drawn up by the US Department of Energy, called the Hirsch Report (2005), begins with the following warning: "The peaking of world oil production presents the U.S. and the world with an unprecedented risk management problem. As peaking is approached, liquid fuel prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be unprecedented." [8] An article published in the daily newspaper *Science* expresses the following: "The world's production of oil will peak, everyone agrees. Sometime in the coming decades, the amazing machinery of oil production that doubled world oil output every decade for a century will sputter. Output will stop rising, even as demand continues to grow. The question is when." [9] Similarly, a statement since 2007 made by the US Government Accountability Office drew attention on the uncertainty of the world oil supply in the future, relying on the premise that overall production will reach a peak and then will begin to decrease "somewhere between now and the year 2040", with most of the studies cited suggesting that peak production will most likely occur by 2020 [10].

There are, however, experts who say that we still have enough oil. The essence of the idea that we will not run out of oil in the near future was expressed in June 2000 by the former Saudi Minister of Oil (1962-1986), Sheikh Zaki Yamani. He stated: "Thirty years from now there will be a huge amount of oil - and no buyers. Oil will be left in the ground. The Stone Age came to an end, not because we had a lack of stones, and the oil age will come to an end not because we have a lack of oil." [11]. Energy Information Administration (EIA), which is part of the Department of Energy of the United States, estimates that only 4-7 percent of the initial quantity of liquid petroleum has been produced. Different people, from those holding executive positions in oil companies to consultants in the field of energy and economists in academia, strongly believe that the worries regarding the depletion of this resources in the near future are premature for various reasons: there is plenty of oil, we have consumed only a small part of world reserves, the technology used for discovering and extracting oil improves constantly, and the desire for profit combined with the law of supply and demand will prevail [12] [13] [14], [15].

There are still many debates and discussions if we have really reached (or have overcome) the maximum rate of oil production, "Peak Oil". However, there is a consensus with respect to the fact that we have passed the time at which the rate of discovery of the crude oil was at its maximum. During the '60s, it has been discovered an average amount of 56 billion barrels each year. Of course, the perception at the time was that we are actually swimming in oil, because, at that time, the consumption was only 10 billion barrels per year. Nowadays, we consume more than 30 billion barrels each year, exceeding by far the quantity of oil discovered by oil companies.

What will be, however, the consequences of "Peak Oil"? Even though it may take several years after the "peak", oil prices will lead, among other things, to the fact that long-distance transport will become too expensive - thus leading to a phenomenon of "re-location", opposite to the present globalization. What will be the advantages, for example, for an American company to use cheap labor work from a third country to produce sneakers, let's say, when the expense for bringing them back into the country will become so large that the business would become unprofitable? "Peak Oil" will question the growth method of world economy, based on consumption. Living standards in the Western countries - and not only - will decrease after the "peak" moment. Even a seemingly minor decrease in production may lead to major increases in the oil price (during the crisis in the

1970s, a decrease of 5% has resulted in increases of nearly 4 times of the crude oil price). And what will follow will not be a simple crisis, but a permanent condition of our civilization. The economic recession is unavoidable, resulting in an increase in the prices of all products, the impoverishment of the population, unemployment and large-scale social unrest, new wars for resources etc. While supporters of alternative energy sources claim that they have a solution to this situation for a few decades, by replacing the energy obtained from petroleum with solar energy, the energy derived from wind power, hydrogen etc., the truth is that our society, with all its complicated systems, is based on fossil fuels. In order to fully restore the infrastructure, we may need several decades, so in a few years this is absolutely impossible. Even the much proclaimed "hydrogen-based economy" is not a solution that can be adopted in a short term. Hydrogen has its role, but this role is not that of energy producer; the cells of hydrogen store energy, but they do not produce it as well. And it takes a huge consumption of energy to produce those cells that create energy. So, at present, fossil fuels are the primary source of energy.

Oil production will decline gradually, and over 50 years after the "peak" will become practically insignificant. That will be the end of oil era. The industrialized society, as we know it today, will no longer exist. And a lot of time for developing alternative sources of energy we don't have.

### **Alternative Energy Resources**

The increase in oil price, associated with estimates according to which known reserves of crude oil shall be reduced in the next 10-15 years by half, force the developed states to turn their attention to renewable energy resources. But alternative energy sources are currently not cost-efficient and they don't even find reason to be in the conditions under which the price of energy is low.

Oil crisis of the 1970s has warned the highly industrialized states that the security of energy supply became a vital issue for them. Expensive programs were initiated for the construction of nuclear power plants and important subsidies have been allocated for alternative energies. The planned interventions of those states have not however shown any results, so that, only ten years later, the responsibility for investments in the energy sector began to be shifted to the private sector. Then, the enthusiasm for identifying new sources of energy dropped significantly, due to the fact that the investment costs were extremely high, but also that new oil deposits have been identified. After decades since the first oil crisis, the world again finds that it is vulnerable when it comes to energy security. The oil era is coming to an end, the specialists consider, but that of renewable energy sources is still far from making its presence felt, under the circumstances in which the European Union is increasingly dependent on imported energy resources. Meanwhile, a new challenge has appeared worldwide: pollution. Under the pressure of the commitments assumed under the Kyoto Protocol, the debates on the "green energy" topic have taken a particular large-scale. European Directive 2001/77 lays down that "the promotion of electricity from renewable resources, in the single energy market, aims to increase the share of renewable energy sources (RES) from 14 to 22% (by 2010) of the gross consumption of electricity in the European Union". The directive also brings a series of measures of encouragement and facilities for those investing in RES. The strategies are followed by deeds only now, when oil announces a new possible world energy crisis. World begins to slowly move towards alternatives to oil, including coal and natural gas, and finds attractive the unconventional sources of energy, such as biofuels, solar and nuclear energy. At a first glance, these might seem like the perfect solution to the oil crisis. Only that they are not. Even

if we should strive to break from the dependence on oil, we cannot do our best, because there are increasingly more financial, political and technical pressures. The best solutions will be those that propose the largest reductions at the lowest costs, in the shortest possible time.

Cars powered by hydrogen, cold fusion and other speculative technologies "sound good", but may lead to spending some valuable resources which could be used for more efficient ideas. "Renewable fuels" also sounds tempting in theory, and the agricultural lobbyists have convinced the US and European States to implement measures to promote the cultures of "alternative oil". Until now, however, ethanol derived from corn in the US or the biodiesel from palm oil, canola, and soybeans in Europe proved to be a disease heavier than oil dependency. Researchers have made the serious error to calculate that emissions will be reduced, because plants absorb the carbon during the period of growth, but they did not take into account the fact that these crops will result in deforestation of the areas which previously absorbed even more carbon from the atmosphere. Indonesia, for example, has destroyed so many forests in order to make palm oil for the European market of biodiesel that it ranks third in the top 21 most polluting countries. But it's not just a matter of pollution; the grain needed to fill an SUV with ethanol could feed a person for a period of one year. However, the United States have increased five times their production of ethanol in a decade and aims to increase it again five times in the next ten years. Therefore, the USA are still supporting the ethanol from maize and, moreover, aim to launch the "second generation biofuels" operation, such as cellulosic ethanol. In theory, they should be less destructive than maize-based ethanol, which is based on tractors, oil derived fertilizers and distilleries with huge carbon emissions. However, recent studies show that any biofuels requiring agricultural land is more disastrous than gasoline regarding global warming.

Another alternative source of energy, nuclear energy, is not guilty of polluting emissions, so that politicians and even some environmental activists have embraced the idea that it is a clean alternative to coal and natural gas, which can also operate in the absence of sun and wind. Several states - France is the most successful example in this regard - are covering a part of their energy requirements from nuclear sources, and other states are preparing to build nuclear power plants as well. But nuclear energy cannot resolve the climate crisis, first of all because the West must reduce emissions now and not in a few years, when the first new reactors will be put into operation. Up through 2020s, therefore, we cannot count on any help on behalf of nuclear energy. Another minus is the cost - nuclear power plants should, at least theoretically, be expensive to build and expensive to operate. Unfortunately, they prove to be exorbitantly expensive to build, in some cases initial costs increasing four times until completion, but also extremely expensive to operate.

Other alternative sources to oil are, in fact, rather "derivatives" of oil, as follows:

- oil extracted from the Canadian sands (unconventional oilfields); the bad part is that the extraction of oil from oil sands is very expensive and at the same time, what's even worse, is inefficient in terms of energy: it consumes a barrel of oil to extract only 1.5 barrels (while in the case of "classic" oil the ratio is 1:30). It is hard to believe that someone will invest an amount so large for relatively modest results. And such an investment will be made only when world oil prices will be extremely high;

- the "abiotic" conception about oil. There is a recent theory, introduced by Soviet geologists in the 1970s, according to which oil has an "abiotic" origin, deriving from some chemical processes of condensation of gaseous hydrocarbons, somewhere in the mantle (about 70 km deep). Most geologists however, do not agree with this ideology. And even if this theory would be correct, the process of renewal, if it would indeed occur, would be extremely slow - at the geological era's level - so anyway it has a too small influence on world conditions in which we live. The decline of oil production has already occurred in about all countries (except for the Middle East countries). For example, in the USA, peak production was reached in the 1970s (at 10 million barrels per day), while today's production is maintained at a level of 5 million barrels per day;

- "synthetic" oil obtained from coal. This technology has been used heavily by Nazi Germany during the war, due to the limitation of oil resources. About half of the oil used by the German army came this way. However, the procedure used is expensive and inefficient: from 100 kilograms of coal are hardly obtained 30 liters of oil. Of course, what the need has pushed the Germans to do during the war might push humanity as well, along with the decrease of the "classic" oil resources. However neither the coal resources are limitless. At the rate at which they are exploited today, they are sufficient for about 200 years, but in the case of an intensive use, of course, they will be finished much faster. Neither the "pollution" factor can be neglected in this case.

- the solar energy, wind energy, tidal energy, geothermal energy. Wind and solar energies suffer from obvious physical restrictions and they would be able to replace only a minor part of the energy provided by oil. Firstly, they lack of what is called "energy density" that oil has. The photovoltaic cells are even less efficient: all solar panels installed at present in the world hardly give the energy of a coal thermal power plant. In addition, wind and solar energy is not a form of transportable energy as is that given by oil and under no circumstances may provide the current network transport: trucks, ships, planes, etc. Another significant aspect is the one according to which, in each photovoltaic cell, is being invested a large amount of technology (extraction of rare metals, for example), a technology that consumes petroleum. As a matter of fact, reality shows that is necessary much more energy to create a photovoltaic cell than we can expect it to give us in return as electrical energy. Things are not very good either as regards to the tidal and geothermal energy - thanks to the high costs of building such power plants and low productivity.

Thus, "Peak Oil" is not a problem that has a solution yet. The global society is operating on the basis of oil and gas, and these resources may not be created out of air.

### **Hubbert's model**

At the beginning of the third millennium, the concept of "Peak Oil" did not exist yet and nobody had a problem that the oil production will decline at some point. However, a discussion about the time when the global oil production will reach a peak began when geologist M. King Hubbert presented his model for future production of oil of the USA in the '50s.

Hubbert was a geologist born in Texas, became an employee in an oil company and an analyst of energy resources. A respected scientist, with a doctorate in geology at the University of Chicago, he has brought a lasting contribution both in the field of oil exploration as well as in the study of the natural movement of groundwater. After a 20-year career at Shell Oil and Shell Development companies, Hubbert has joined the specialists working in US Geological Survey (USGS) in 1963 and started to teach at Stanford University. In 1973, he was appointed Professor at the University

of California in Berkeley. Hubbert has retired from the academia in 1976, even though he remained affiliated to the USGS. He has published more than 70 articles, and his works are still taken as a reference. During his life, Hubbert's fame was recognized, being elected member of the National Academy of Science in 1955 and of the American Academy of Arts and Sciences in 1957; he was president of the organization Geological Society of America in 1962 and in 1977 he was awarded the Rockefeller Public Service Award. Hubbert was not appreciated only in the scientific circles for his publications, but he also enjoyed the media's attention when it came to energy resources. Throughout his career, Hubbert has offered various predictions with regard to the decline of world oil supply, his predictions regarding the moment of reaching the peak ranging between 1990 and 2000. His predicted dates were premature, but in the general scheme, they do not differ significantly from those made by current analysts. Toward the end of his active career, Hubbert repeated the same grim message that he has advanced in the preceding earlier decades: "It is difficult for people living now, who have become accustomed to the steady exponential growth in the consumption of energy from the fossil fuels, to realize how transitory the fossil-fuel epoch will eventually prove to be..." [16].

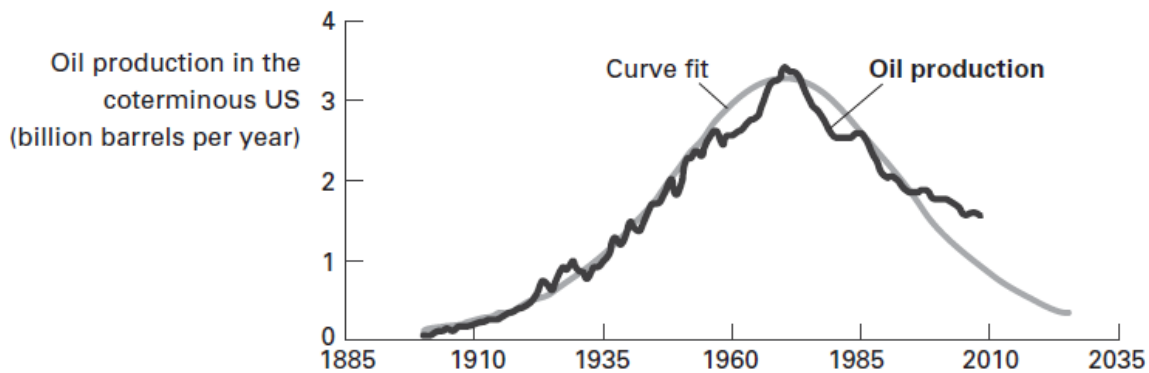
In 1956, Hubbert predicted an oil crisis in the United States in the early 1970s. Despite his position in society, his statements were regarded with skepticism. And yet, around 1970, the United States have experienced an oil crisis. Then, Hubbert predicted that the world oil production will reach its peak in 1995. This did not happen, many believe that due to the oil crises and the diminished production from the 970s, the process was slowed down.

At that time, Hubbert was working for Shell Company and his model was discussed for the first time in the conference organized by the American Petroleum Institute (API) in March 1956, in Texas. Hubbert's work was entitled *Nuclear Energy and the Fossil Fuels* and has been published by API at the beginning of 1957, in the publication *Production Practical*, making it thus available to all members of the API. According to one of Hubbert's statements, Shell Company was organizing internal course for its employees, in which he was presenting his work. Thus, since that year, Hubbert's model has been known by the oil companies, but it was not a subject discussed open publicly, being kept under silence for a while.

When Hubbert developed his model, he was not concerned about the rate of oil production, but especially about the discovery of new reserves. Statistics show that the discovery of new reserves in the USA (in the 48 states to the south of Canada) has reached a peak in the '30s and began to decline in 1955. We all know that oil is a finite resource and that the day when it would end will come. Between the first discovery of oil and the time when the last barrel will be extracted, there is a peak. This peak (referred to as "Hubbert's peak" or "Peak Oil") is the moment when half of the oil reserves have been reached. Even since the theory developed by Hubbert and up until the present time, there are countless discussions with respect to the time this peak will be or has been reached. At the time of issuing the theory, Hubbert has estimated that this moment would be between 1965 and 1971. There are specialists who support even today Hubbert's theory and declare that the peak was reached in 1971, but there are also specialists who continue to claim that this peak has not yet been reached and that the planet has many reserves of this valuable resource.



Hubbert's approach has been to take over oil production data over time and adapt to these the logistic formula (his bell-shaped curve). The approach is attractive because everyone can reproduce it by adapting it, or by a similar bell to the production data before "Peak Oil". Hubbert has noticed that, after oil was extracted for the first time in the 1860s, there was a rapid growth and then a decline in the discoveries of new oilfields within the USA, and the peak of oil discoveries took place in the mid-1930s. He predicted that production will be followed by a similar decline.



*Oil production of the US lower 48 state and Hubbert's curve (source: EIA)*

The figure above shows the logistic curve that fits the historical data relating to the oil production until 2008 in the United States from southern Canada. One of the main criticisms of Hubbert's model on the production of resources, raised by some analysts, is that the model assumes that maximal oil production occurs when half of the ultimately recoverable resources has been produced. These analysts assert that maximal oil production can also be reached when more than 50% of the ultimately recoverable resources has been produced. Further studies on the depletion rate of the recoverable resources argue that "Peak Oil" production at 50% of the ultimately recoverable resources is not an accurate reflection of reality. However, some researchers sustain the opposite of what other critics of the Hubbert's model expect, that "Peak Oil" production tends to occur when less than 50% of the ultimately recoverable resources has been extracted. This means that, putting the production data into a Hubbert's model to make predictions on future production, may result in an underestimation of future production.

Historic development of the curve until 1956, when Hubbert made his original prediction, matches the data on oil production. The start-up period of the production and use of other resources tend toward a fast exponential growth. As time passes, the oil production increases, but the growth rate has slowed down to the "Peak Oil" production (approximately 3.5 Gb per year in the 48 states of U.S.A. at south of Canada). The date corresponding to this peak (that took place in 1970) is what specialists name "Peak Oil". After this, reserves are assumed to deplete faster than the oil production from new findings can compensate for. After this peak, the curve drops to a level of nominal production. Ultimately, resources are depleted when the cumulative production is approaching the value of oil reserves. Between 1972 and 1976, Hubbert has extended his analysis

on the depletion of world oil reserves. He made forecasts in time, with the peak occurring in 1995, 1996 and 2000. Hubbert applied his approach using values of the world oil reserves ranging between 1.35 and 2.1 Gb.

When Hubbert attempted a similar analysis for the rate of oil production as well, he estimated that the peak will be reached in the 1990s. But his model does not apply as easily for production as well. In the first place, because there are plenty of oil producing regions, each with its maximum rate of production, therefore it is necessary that they are analyzed individually. The fact that, for political reasons, oil production has been restricted in the late 1970s and early 1980s is another important factor. However, there have been theoreticians who have tried to apply Hubbert's model in different regions of the world, managing thus to describe at a large scale the course of history. Anyway, all these curves have a maximum when half the oil reserves have been produced, and detailed analyses of what really happened in different regions of the world provide a different and more complete picture.

Hubbert's model is a rather mathematical one than based on physical elements. In the model, data are comprised in a mathematical curve and Hubbert's modeling assumes that the maximum point occurs when half the resources will be produced. The geologist Colin Campbell has introduced two major changes in Hubbert's model: first, he began to apply the model on each nation and the second, he has taken into account the "depletion" of resources ("depletion" - how much from a reserve or from a particular region, of the total oil reserve which may exist at the beginning of each year, may be extracted). Campbell's method asserts that the rate of oil production does not have a symmetrical history. This means that the speed with which oil production increases before the peak is not necessarily equal to the speed with which decreases after the peak, and the peak does not occur when the half of oil reserves in reached.

The researchers who sustain Hubbert's calculations, by making their own calculations, believe that "Peak Oil" will be reached no later than 2050 or perhaps was already reached in 2004. Estimates with respect to the time when this phenomenon will occur are different, but all of them, even the most optimistic ones, agree that oil is a finite resource and that the time when the resources will be depleted will come. Already some of the world's resources have been depleted or their production has decreased; the same thing is going to happen soon with others as well. Only the Middle East shows no signs of weakness so far, sustaining the world production figures. More than 70% of the remained oil reserves are located in just five of the countries in the Middle East: Iran, Iraq, Kuwait, Saudi Arabia and Oman.

Many analysts have stepped in Hubbert's footsteps and made their own predictions. There are plenty of studies on the peak of oil production which show how different are the opinions on the value of oil reserves and on other factors. A study from 2004 on the depletion of oil has been published in the daily newspaper *Energy* and has addressed the issue of the timing of the peak production under a series of assumptions concerning the oil resources and future demand. The model in this study is much more complicated than that of Hubbert's, but the central idea is the same. The authors conclude that "global production of conventional oil will almost certainly begin an irreversible decline somewhere between 2004 and 2037". No less troubling, the study shows that the demand will convert net oil exporting counties in net consuming countries and that the

number of exporting countries will drop from 35 at that date to a number between 12 and 28 states until 2030 [17].

Although the term "peak" suggest a smooth curve, with production increasing slowly up to the midpoint, then dropping to zero, in the real world the fall will not be one smooth ride. As we are approaching the peak production, the increasing prices will encourage oil companies and states to wander around the world in search of oil. For a while, they will succeed, finding enough oil in order to maintain production at the same level, transforming the "peak" in a sort of "plateau" and, perhaps, temporarily driving away fears. But, as a matter of fact, this insane "post-peak" production will only deplete even faster the remaining resources, thereby making the final decline to be even more abrupt and sudden. And, although we will not run out of oil tomorrow, we are approaching the end of what might be called the "easy oil". Even in the most favorable conditions, the remaining oil will be more expensive to find and to produce and more uncertain than the one we use today. That means not only higher prices, but also more volatile, which will make it more difficult to observe how fast oil reserves are consumed and very difficult to know when we will need to start looking for something new.

#### 1. **So, when do analysts say that "Peak Oil" will occur?**

Surprisingly, projections do not differ to a significant degree. The major collective estimate is that the peak of global production will occur before 2025, with more pessimistic analysts which suggest that this time has already passed, only that we just don't know yet, and the optimistic push this date as being more close to 2050. For example, CERA (Cambridge Energy Research Associates) continues to advance the idea that "Peak Oil" will not occur until after 2030 [18].

The fact that so many analysts have come to a general agreement on the time when oil production will reach the peak is not a surprise, because most of them use the same basic method for forecasts. Even if the approach is different, they base their forecasts on the original method proposed by Hubbert, who initiated the scientific debate from our times with regard to oil depletion. Over time, criticism and improvements have been brought to the model, but Hubbert's model and many of the models developed later are based on an estimate of the total world oil reserves. Thus, the quantity of oil which can be consumed according to most models is the same. The only difference lies in the direction that everyone sees for the production of oil in the future. During the period in which Hubbert has developed his model, oil discoveries were reduced and thus he based his forecasts on restricted information, so that his model is useful for rough estimates of the oil production rate. Nowadays, there are already much more information with regard to the history and practice of oil discoveries and production in different regions of the world and in the different oil fields, which allowed the researchers in the field to improve the model in order to forecast the future production rates.

## **SHORT HISTORY**

### **The 1916 and 1918 crises**

One of the first major fears concerning the depletion of oil has occurred at the beginning of the twentieth century. The Model T Ford was a novelty in 1908, with sales of just 10,000 cars. Until 1914, however, sales increased to 200,000, with a gasoline price of 16 cents per gallon. Oil was

plentiful and oil saturation in 1914 has led to a decrease in the price from \$1.05 to \$0.55 per barrel. But, in July, the First World War has begun. A few years before, in 1911, the US naval forces began the production of faster oil-based cruisers, at the expense of coal. Similarly, in 1913, Winston Churchill began the transformation of the British fleet of cruisers to operate with oil. Thus, with the First World War in full progress, there has been a violent "clash" between the demand too high and the supply too low. In 1915, the demand for fuel due to both military and trading vessels was added to the fuel demand for 2.1 million cars in the United States. The supply situation, also, changed that year, with an unexpected decline in the yield of the oil deposit Oklahoma's Cushing, at that time the most productive region in the world. In 1916, the crisis "fooled around", with the oil price from Oklahoma jumping from 40 cents per barrel to 2.05 dollars per barrel.

The crisis was over at the end that year, when two things have happened: refineries have adopted the new technology of oil "cracking" to produce gasoline and, in addition, the high prices have resulted in more drilling, issue that has led to discoveries both in California as well as throughout our continent. By the end of the year, oil price has decreased from 2.05 dollars to 90 cents per barrel.

The silence lasted for a short while. By mid-1918, in the USA were nearly 5.5 million motor vehicles, and the war has led to the necessity of transporting the oil across the ocean. The United States have produced only 400 planes in 1916, but this number increased in 1918 to over 11,000 (US Air Museum, 2007, Duxford, UK). The excessive fuel demand has pushed the Administration of those times to appeal to the patriotism of citizens to join the "Fuel Free Sunday". Oil depletion was again the watchword of the day. In 1919, Gilber and Pogue, of the Smithsonian Institute, asserted that [19] "there is no hope that new fields, unaccounted in our inventory, may be discovered of sufficient magnitude to modify seriously the estimate ...[The war] has merely brought into the immediate present an issue underway and scheduled to arrive in the course of a few years". The crisis continued into 1919 with a dreadful forecast of David White, Chief Geologist at the USGS, that the "peak of production [in the USA] will pass soon - possibly in three years" [19].

However, when the war ended in 1918, the demand began to decline, and at the same time, the increasing oil production in Texas has helped to increase the USA supply with more than 1 million barrels per day in the following year.

The threat that oil will become scarce became a serious problem during the 20th century. Below we have a notable quote for that period, just before the entry of USA in the Second World War. "...it is unsafe to rest in the assurance that plenty of petroleum will be found in the future merely because it has been in the past." [19]

### **The crisis in the 1970s**

In 1973, OPEC increased twice the price of oil. The first increase of 70% was simply to show their power. The second increase was linked to the Arab-Israeli war, which began when the forces of Egypt and Syria invaded Israel in 1973, on the day of Yom Kippur celebration. Several countries have supported back then Israel, including the USA, the Netherlands, Portugal, South Africa and Rhodesia. Indignant, OPEC has established an embargo, refusing to sell oil to these countries; they

cut off the supply by 5% per month to the "unfriendly countries" (that is, countries friendly to Israel). Overall, OPEC has dropped production by about 21-16 million barrels per day (meaning more than 23%). Production increased rapidly in the rest of the world, to counterbalance production reduction within OPEC, so that the world reduction in production was only 9% of the global supply. This apparently small reduction, combined with the uncertainty caused by the embargo and the events of that time, has led to a dramatic increase in the price. Saudi light crude oil has increased from \$1.90 per barrel in 1972 to \$9.60 in 1974. Panic was installed in the markets. USA gas stations have run out of oil. In the USA, retail price of gasoline has increased by 40% in 1973, long queues of cars were formed waiting for gasoline supply, and sale was often restricted depending on the odd or even number of the license plate.

Although the OPEC embargo was lifted in March 1974, the oil production remained low, and prices have continued to grow. Was the world running out of oil? President Jimmy Carter so believed and asserted in 1977 that "We may finish all proven reserves from all over the world by the end of the next 10 years. ..." At the same time, the National Energy Program of the Executive Office of the President, decreed: " The diagnosis of the U.S. energy crisis is quite simple: demand for energy is increasing, while supplies of oil and natural gas are diminishing. Unless the U.S. makes a timely adjustment before world oil becomes very scarce and very expensive in the 1980's, the nation's economic security and the American way of life will be gravely endangered." [19].

In 1979, the regime of the Shah of Iran was overthrown, and the export of Iranian oil has ceased for 9 months. Back then, Iran was the second largest oil exporter in the world, and the oil shortage caused prices to increase again. Iranian light crude oil price has increased from \$13 to \$ 30 per barrel in 1980, and the Saudi light crude oil price has increased from \$12 per barrel in 1977 to \$26 in the same time period. The panic on the markets was rekindled.

The world oil situation has determined the CIA to report in 1980: "We believe that worldwide oil production probably has reached the peak ... In simple terms, the expected decline of oil production is the result of rapid depletion of crude oil accessible deposits" [20]. By 1982, the Saudi light crude oil has reached \$34 per barrel, almost three times higher than it was five years earlier. During the period of price increases, world economies have suffered due to the boomerang phenomenon of the inflation rate. From 1972 to 1980, the price of the goods and services in the United States has doubled<sup>1</sup>.

As can be seen above, throughout the 1970 and into the early 1980s, oil price has increased and has created difficulties and uncertainty, but those who have concluded that the world is depleting its oil were mistaken. In the mid-1980s, world has experienced again a saturation with oil and, until 1989, the price of Saudi light crude oil was \$13 per barrel. The Government's directive on conservation and the discoveries of new oilfields were "responsible" for this saturation. In the USA, the economy standards of fuel consumption by federal cars, instituted in 1975, have mandated that, over the next 10 years, the autonomy of new cars must be increased from an average of 13.5 to 27.5 miles/gallon. The discoveries from Alaska, Mexico, and the North Sea added to the

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<sup>1</sup> CPI (Consumer Price Index) has increased from 39.8 to 86.3 between 1971 and 1980, [ftp://ftp.bls.gov/pub/special.requests/cpi/cpiiai.txt](http://ftp.bls.gov/pub/special.requests/cpi/cpiiai.txt).

global reserves. After the completion of the Trans-Alaska Pipeline in 1977, oil from Alaska began to flow into the rest of the United States, reaching in 1980 to 17% of US production. The "oil crisis" of the 1970s, with high prices of oil and imminent global depletion, simply has evaporated.

## CONCLUSIONS

Like any other resource, the oil also will have a moment when it will become insufficient for the world's needs or when it will end. How close or far is that moment, it can hardly be estimated, because of so many reasons. Also, the „Peak Oil” cannot be only a theoretical concept and it really exists. It existed for everything. It may be applied for almost everything. It's not that difficult to imagine that the production of a resource, whatever the resource, constantly grows for a period then starts to decrease. Why would it be different for oil? The world is still in a febrile search of this resource and oil is still indispensable to a modern economy. The annual production is growing, so is the consume. But the growth rate already started to decrease or stagnate. Although there still are some “explosions” of oil productions in some world areas or in some moments, they are sporadic and don't have the consistency they once had. Nor the military or political conflicts are as frequent or important or destructive as they used to be.

In consequence, we believe that the “oil era”, as it is named, will come to an end. Not because we will suddenly be out of this resource or because the planet will run dry. But because, before these happen, the mankind will find new ways to evolve and manage.

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