

## Peak Oil: Production Forecasts and Implications

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Good afternoon, ladies and gentlemen. I'm very pleased to see you in such numbers, in fact, slightly awed. So, let me get straight to what I wish to talk about. In the next half hour or so, what I aim to show you is that Peak Oil isn't some exotic theory, it isn't some event for enthusiasts; it's an emerging reality. It's just a case of joining up all the dots, the pieces of information we have, and we will see that, as I hope to demonstrate to you, that it's quite clear what is happening.

Now, the evidence suggests that within about five years, global oil supplies are going to peak. They will then move into an initially gentle but accelerating decline. Now, this is going to be a major historical discontinuity. It's a discontinuity where I hope to show that market economics is not actually going to help us very much. However, it's not the end of the world, you know, this is not some apocalyptic scenario; humanity is ultimately very clever, very able, very adaptable, and we will adapt to this challenge, and we will find ways of doing things possibly a little differently from the way we do it now, so my message is quite straight forward, that the sooner we recognise what's happening, the sooner we can start preparing for this adjustment which we're going to have to make, and the converse, the later we leave it, the more uncomfortable this disruption is going to be.

Now, I'm not always great with technology, so I think my only observation at this point is that perhaps we could have this mobile microphone on? My key message here is actually to let the information talk. We all have hopes and aspirations; to be a good analyst, you need to take yourself out of the situation. It's terribly easy to see what you would like to see in the numbers, in fact, the key thing is to just see what the numbers actually say. Similarly, it might be a somewhat cynical observation, but companies are constrained to make all sorts of public statements, for all sorts of good and less good reasons; the key thing is to watch what they're actually doing.

Now, the energy institute that I work for is necessarily a broad church and therefore I have to put this disclaimer in just to reflect that. As I've indicated before; the key thing is to recognise that this is a challenge that is real and imminent and that time is really not terribly long and it's not going to be that easy to adapt. The fact that we will succeed in adapting is the key thing, the idea that it's difficult is the reason that we've got to get on with it.

So, what is Peak Oil? Well, it is relatively straight forward. Rather than reading it out, the analogy I like to give is; however strong you are, if you keep throwing a cricket ball in the air, you will only succeed in getting it so high, and in effect, what you're doing is, you're balancing gravity and your strength. In the case of oil, the "your strength" is the new projects coming on, the new flows of oil and the "gravity" is the depletion of the existing stock of oil fields, the way that they necessarily run down.

I think the first thing we perhaps need to recognise and it's not always well recognised, is that the world wants production flows. It wants a flow of the material. So, if you go down to your filling station, you want to fill up your vehicle now, you don't want to be told "Come back in three months." You'd be very alarmed if you heard that. You'd be fairly alarmed if they said "Stick the hose in the back and come back in six hours." So, the key idea here is that it's flow. People spend a lot of time talking about reserves, which are a stock, reserves are necessarily difficult to estimate and evaluate; they only become of interest to the consumer, to the business man, to the country, when they're turned into flows.

Now, this is a topical oil field because it's the Alaskan North Slope, where BP has had considerable problems with corrosion and half the field has currently had to be turned off while a rather

expensive refurbishment program takes place. Now, from this diagram, which is actually fairly typical of an oil field profile, we can see a number of key things. The first thing is like most big projects; it came in late, nothing too alarming about that, expensive development. The second thing is; they wanted to get to peak production as quickly as possible. That's because you want to get your money back, or you've got, in the earlier years, you've been spending out, now you want to get the return on your investment as quickly as possible. In this case, you have a plateau which was put in by the constraint of the pipeline across Alaska. Very little point in investing to have full peak there, so you choose a most economic level, which is the one they did there. You'll see that, in fact, taking into account the delay; the field produced more or less as they planned. However, they then found that because of higher prices, because of the need for supplies, that they were going to be able to extract much more oil out of the field and the effect of recovery was going to go up hugely, so that's a tremendous success at a technical level. That's a real change. However, the problem is that production is going to fall, because once you come off plateau, production declines every month, every year, and just goes down this curve. So that is a quite difficult business model to cope with, because in effect you have less oil to sell but your costs are either fixed or rising, so your unit costs rise all the way down this.

Now, in an environment of high oil price inflation, that is easily covered; that is not a problem, but you get to the position where we are now, which is 2006 here. Production is way down, the level is quite low, you're suddenly having to expend a great deal of money to restore what will still be a fall in production. You have got a political problem because the Governor of Alaska is very dependent on the taxes you pay, and doesn't believe he should be short changed on the taxes just because you have got your oil field off stream. So here you have two classic problems of a mature field; the "How much money can you afford to keep spending?" It's a bit like an old car, you can keep replacing the parts, you can still make it run, but it gets more expensive and you've still only got an old car, and there is the political complication that, in any part of the world, governments very quickly get used to oil revenues and are very reluctant to accept the idea that these may be declining.

The final point I want to make is that in virtually any oil field on earth, with enough investment you can pull this boot right out, so you may go on producing for a very long time. There's a field in Texas called the East Texas Field, which is the biggest field in mainland America, if I can put it that way, which came on stream at one hundred thousand barrels a day in 1930. It's still producing one hundred thousand barrels a day; it's just that ninety nine thousand of them are water, so in effect, you can squeeze an oil field an awful long way. You get these recoveries higher and higher, but your challenge is that the production is falling and, of course, the world wants increased production flows and once you've got too many old fields in that position and too few in that position, then the world necessarily tips over. So, it's simply a mathematical phenomena in that sense.

Now, this is just trying to reinforce this idea of the scales; so, in effect Peak Oil is going to occur much earlier than many people think, for no other reason than you only require fifty one percent of world production to be declining, and then it cannot be off-set by the forty nine percent that's still expanding. So, at the point of Peak Oil, you'll be still finding oil, you'll still be developing fields, there will still be good news from the industry in that sense, it's just that the weight of the elderly fields in decline will have overwhelmed what you can do in terms of new capacity.

Price becomes very dramatic if you plot it as an annual one; as you see, up to 2003 it was moving at a narrow band of around \$30, since then it's headed steadily north, what's it telling us? It's telling us "Send more oil." The fact that we can't get any more oil means that we have to then ration off the demand with a high price. So, the key line in any economics text book is this one; that supply and demand must always balance, and we've rather easily assumed on the fairly good historic experience that, whenever demand ran ahead of capacity, a high price signal would draw forth the supply and the thing would reconcile relatively comfortably, maybe with a bit of a price wobble.

Now we're into a world where supply can't expand and we need high prices to destroy demand. So how high do these prices need to go? Well, the Canadian bank CIBC, about eighteen months ago, did a projection going forward. So they assessed a shortfall; that's the amount we're short, which, if it was there, would push prices back to about \$30 and the price was the price

they thought the world would reconcile at. Well that, if anything, is looking a little bit low for this year; we've been solidly over \$70 since about May. 2007 I think their estimate was about \$75; that looks about right. Again, it may end up being higher, so the key question is; if they're right with the slopes of their graph and their curviness, and so far they're looking quite good, can our economies actually withstand prices like this? We've been pleasantly surprised that so far our economies have held together, that the pain has not been very visible to us. That's partly because the real pain is being taken in Africa and South America and Asia, where people who might have expected to be doing things, aren't doing them. If you like, the aid flights that aren't flown, the children who walk to school who might have taken the bus, but we don't see them. We don't see the events that didn't occur, so for those of us living in the prosperous parts of the world, you know, high prices have been little more than a nuisance, a pressure, something to talk about at the bar, but whether it can go on, I think is the key economic question. Can our economies withstand those sort of prices, if they're right, or will we start sliding into economic setback and recession?

This is just an attempt to show what's happening rather more visibly; the basic existing oil fields around the world are...their capacities are eroding at about five percent a year. The oil industry is reasonably happy to use that number, so that's the number I've used. If the price was \$30 then demand would go up fairly steadily at about one point seven percent a year, which is the long run rate. That's ignoring any specific sort of China, India impact. My best estimate, and this is slightly artificial for the purpose of the illustration, of the incremental capacity we're putting in, either in the form of big projects or in the form of more intensively working the existing assets will bring us up to this sort of supply line. Now, supply and demand, necessarily, have always got to meet, so these two lines have got to be put together. Historically, we always manage to do it by pushing the new supply line up with new capacity in some shape or form. This looks less likely. You can bring the demand line down two ways; you can bring it down the nice way, which is to use the fuel more efficiently so that you're doing more or less what you intended to do, but using less fuel to do it, or you can do it the less pleasant way which is economic setback and recession where you, in

effect, don't do certain things because you can't afford to do them.

So, why are oil supplies peaking? Well, essentially that's the list; we're not finding oil fast enough, we're not developing fields fast enough, although the companies are in fact pretty well flat out. There are too many of the geriatric fields. People and equipment are moving at a real deficit, which is leading to significant oil field inflation. IHS, which is a major sort of database in the industry estimated oil field inflation at sixteen percent in the last quarter of 2005, which is fairly frightening.

So, how soon is it all going to peak? Well, before we go into that, this is just a standard Discovery map; very briefly those were the big Iranian fields before the Second World War and one of the Saudi fields, what I call "the golden age of the oil industry" with a peak in 1965 and it falls away to the oil crisis. All this period, this entire discovery, was done against really very low oil prices. You can't argue that it was prices driving the exploration. Exploration has been driven by the opening up of areas and the increase in knowledge. Demand, you see, was steadily growing to this point. This is the first oil crisis, 1973, when of course the prices went up and you can argue that the development of the North Sea was at least partially price driven. That's mainly the North Sea but there are other bits that came in at that point, and you had the demand setback from the very high prices. Since then, we've built up steadily to about thirty one billion barrels a day in 2005 and the discovery has gone on down. That's probably associated with deep off-shore, that's probably associated with the Caspian. Latest estimates are always a bit vague on things like discovery; we could have discovered as little as seven billion barrels last year, against a requirement of thirty one. The average for the last ten years from CERA, which is one of the big consultancies in the area, is about eleven point five, but as you see, in order to meet a requirement of thirty one, with a discovery of eleven point five, you've got to take a lot out of the store house. Only the store house is, in effect, running down.

How am I doing for time? Not too badly. This is a rather complicated diagram just trying to show how we build our supply, predominantly from known reserves, a little bit of bio fuel and others, a little bit of <inaudible> and heavy oil. Not in production of the stuff lined up to be developed, enhanced oil recoveries,

squeezing the rocks a bit harder. Now, a lot of talk about the potential of things like the high Arctic, but in the high Arctic, there's no licensing, there's no infrastructure, the ground heaves as the permafrost melts. There are a hundred and one problems and we don't even know what might be up there, so, even if it proved to be a heroic area, it would be anything up to twenty five years before it turned up as stuff we could put in our tanks. Take something much more immediate; Angola has just re-licensed some areas off-shore. Highly prospective, a very good chance of finding more oil, even if we find it this year, in other words straight away, put it into a project in 2007, typically a project is taking about six years from the discovery of oil or the confirmation of the oil to when you deliver oil to here. So, if we find something good in Angola, we're not going to see it until 2012 / 2013, so the die is cast quite a long way out.

How geriatric are the fields? Well, fairly geriatric. First of all, there's this concentration effect that fifty percent of total production comes from just one hundred and twenty fields, and secondly, we have seventy percent of production coming from fields that are over thirty years old. Now, you know, you can take an old man out for a long walk, but don't expect him to do a lot of sprinting, and that's really the position we've got to in the oil fields of the world, so, rather like the end of some catastrophic warfare, where you become dependent for your soldiering on old men and young boys; that's essentially what the oil industry has got itself into now.

Look at some standard statistics; the purpose of this is just to show you that the peaking of oil is not some fevered imagination, it's not something for the future, it's already here. The OECD area is obviously our triple A style rated area; that's where we're happiest to invest money, that's where the rule of law applies and we can see a proper return on our money. It peaked back in 1997 and is producing two million barrels a day less. That's fairly chilling. The North Sea, which is a key component of that, peaked back in 2000 and that has actually declined by nearly twenty percent in five years, so that's pretty frightening.

Now, off-shore declines are much faster than on-shore declines, but an increasing proportion of supplies coming from the off-shore areas. So, without labouring it too much, again, the most surprising one to me is; if you collectively put all of North America

together, although Canada is still going forward, the area's largest production occurred back in 1997, and is unlikely to change because Mexico is now going down quite rapidly. So, our only sort of triple A style area is Canada, and Canadian tar sands are ultimately not the world's most attractive resource; we've seen huge inflation in the tar sand areas, Shell has just announced a tripling of the costs on the latest <inaudible> crude expansion. Total has just cancelled out a project because it felt the costs were getting out of hand, and if you're lucky enough to own a bulldozer in the area, I'm told you can get \$3,000 an hour for its use.

So, the bottom line really is that we've now got to the point where about twenty eight percent of global production is coming from areas that are in sustained decline. They are producing less each year than the year before, and if we just look at the UK North Sea for a second, that's just the day to day, month to month sort of figures. As you see it's sort of ragged but, if you put a trend line through it, it's pretty solid. People spend a lot of time telling you how it's just about to turn around and how it's just safe, unfortunately, it's not quite true. That trend line has been the least inaccurate predictor for the last three years and it gets you to a level of about one point two five million barrels a day, because you've got some gas liquid in 2010, from a peak of two point seven in 1999.

A very typical oil field profile; this happens to be Forties in the North Sea, the normal thing. Try and get your money back as quickly as possible, try and get it up onto its peak as quickly as possible, peak a little bit ragged but some are much more ragged than that, then it goes over the edge onto this sort of ski slope. They tried to arrest this with a fifth platform here, it had a fairly temporary effect, went on down and then the ski slope sort of runs out at the bottom and here, Apache took over, spent a great deal of money and have got a very small uptake in the production. You can get oil field profiles that are similar to that all around the world. Sometimes you have much more difficulty and you get gaps in them and very wide swings, but that's a predominant pattern.

Oil companies themselves. Now, these are the people with the money, with the technology and not all the access they want, but certainly fairly wide access around the world to develop things.

This latest, 2004, you saw reasonably chunky expansion for oil supply. By 2005, it seemed to be petering out. If we roll forward into the first half of 2006 we have a very mixed pattern; BP is a little bit down in the first half of 2007. Exxon is up, quite usefully, because it has a series of West African fields that have come on. Shell is down six / seven percent. Total is down a spectacular ten percent. Chevron is difficult to decode because they've taken over Unocal and you tend not to record the oil that might have been there from a company that no longer exists. Conoco Phillips did the same thing; they took over Burlington Resources, so notionally, their production is up significantly. I haven't had time to de-code whether it's up, taking into account the merger. We're seeing annual decline rates of five percent and individual quarterly decline rates of eight per cent or even higher. So, it's real and it's even happening to the people who have the best equipment, the best technology.

Those happen to be the five largest countries in decline last year. The States is slightly exaggerated because you can regard the hurricanes as anomalous. How anomalous, we don't know. Maybe we have to factor those in. They certainly destroyed capacity. It's fairly predictable which countries are getting to the point where they're having difficulties with saving their production, so the top four went over in 2005, Denmark quite clearly, Mexico quite clearly. Malaysia, because it has some project left, might just come back for a bit, Vietnam similarly. India has done quite well recently but is likely to go about that date, China about that date, so that's another twelve percent odd of global production and we've got a wild card because Iran is really struggling. It has new projects that are not coming on stream, it has political hype with the west. We don't know how that's going to pan out. We don't know if they're going to be able to bring that capacity that they might bring on, on or not.

2005 is quite an interesting year because in effect, the world had no spare capacity at all. A little bit of notional spare capacity in Saudi. This allows us, for the first time, to do a sort of cheque balance, an accounting balance, and what we find is really rather discouraging because globally, the world invested, I believe, to a gross capacity of about two point six million barrels a day and ended up with just over one million barrels a day of oil to sell. Now, that's not quite what you want to do. So, we can then do a more general balance sheet; as of 2005, about twenty eight per

cent of supply was coming from areas in decline and that's going to reach about forty percent by about this date. Obviously there's a little bit of slack and a little movement from that; this is just a balancing item, so the areas where production is clearly growing is going to decline from just under half of the total to just under forty percent of the total in the same period. Russia, in a rather curious way, seems to be holding its share of global production steady for the last year or two. How much that's an act of policy and how much that's an accident I can't really tell you.

So, we have a potential balance in the scales as early as this date, so then we're in all sorts of strange hands. Mr Putin is very keen to rebuild the power of the Russian State using oil and gas resources in particular. So, does he trigger something off or does he elect to be a good supplier to us? We know the Saudis are having great trouble; they're spending lots of money just to maintain capacity at the moment. All the best drillers are out there, all the best completion engineers. The other companies are moaning that the Saudis are paying telephone number salaries, so if you know anyone in that position, they'd be wise to book a plane; they'd be able to retire quite quickly thereafter.

So, these are two big sort of wild cards that could, in effect, tip these scales, or maybe we can drive it out to ten to eleven. So that's the next bit.

Now I, over the last three years, have developed a database of all the main upcoming projects that will produce more than fifty thousand barrels a day, and I've now done it for long enough that I'm reasonably confident about the accuracy of it. OPEC recently has become much more forthcoming about its future production or what it intends to do. They have a website; they rather cleverly don't put dates on the website, but they do revise what they're saying on that website and you're actually seeing a shading down in some of the future capacities and a slight slippage on some of their dates. I then attempt to allocate the start up by the date it's expected to come on and give a build up. For the off-shore this is reasonably straight forward, for the on-shore it's a little harder. It seems to work reasonably well is all I can say, and then, because historically you would have looked at future demand and then looked at the supply needed to meet it, which is the classic IEA way of doing it or the EIA way of doing it, but if you believe supply is fundamentally constrained, it seems better to turn it the other

way around and see what is left to meet the demand. So that's in effect what I do.

Now, if you just plot it as gross new capacity, and there are people who do this, you get huge capacity coming on stream and then you get this rather dramatic fall off, which is not planner's droop because it's too early, this is projects you would have to know about now if they were to come on stream then. If you plot that just against the likely long term demanding of these, you would think that there wasn't a care in the world, that there was plenty of oil and the price should be crashing down and your only mystery would be how someone had manoeuvred the price up to \$70. So, the reason that's not right is perfectly simple; it's the reality of depletion plus a series of other negative factors.

Now, projects slip; I revise the database all the time when data comes out. Obviously the companies don't draw attention to their misfortunes, so I find I need to add about another twenty percent to balance that factor out. It sounds very dramatic, but twenty percent in a year is just two months or just over two months. You saw those sort of ragged peaks on the individual fields where we got monthly production, now the companies tend to quote the top of the peak, which is reasonable enough in their terms, but to get the average flow, you need to take about ten percent off. A figure that was advised to me by one of the oil companies.

We can establish that depletion is this much, we just take the standard figures, we put all the countries that are in decline, we look at their this year's numbers versus last year's numbers, so that is a quite robust number. We also know it's rising.

Enhanced recoveries are a very variable feast; you can get all sorts of numbers, but the long term average seems to be about half a percent a year. We get lots of stories about depletion rates rising. I'm still sticking with the five percent because, until I get more convincing numbers, more convincing data, that it may really have risen above that level. We know about the number of countries, we also know that pretty well ninety percent of all known reserves are actually in production.

So, now we can turn it around. What we do is; we deflate the gross number by the slippage, which overtakes itself eventually. We take off the ten percent for the actual flows. We've got two good data points there, we take the fairly conservative assumption

that it just continues on this trend line for depletion. That allows us to create the net availability of oil and what we see is that we have a reasonable flow from here, into 2010, and then it drops away quite abruptly and Peak Oil in that one occurs in the first quarter of 2011.

Now, what I have done is; I've altered all sorts of depletion assumptions and I find that, if I put the depletion up by thirty percent or down by thirty percent, I move Peak Oil forwards or backwards about three months. It's a surprisingly small movement, so then I tried putting all the possible projects that have conceivably, in their wildest dreams, come on stream, and then you can move Peak Oil almost a year, but you've got a really, fairly ridiculous assumption.

We have a complete wild card to take into account, which is that most of the oil producers subsidise usage. So, if you go to Caracas, gasoline costs you \$0.07. If you go to Riyadh, it costs \$0.10, it used to cost \$0.20 but the government decided that you need some help. Similar in all the OPEC countries and, even in Moscow, gasoline only costs you \$1.50, so in effect, what is happening is; the producer governments are giving a reward to their populations and there is no pressure on them to alter this reward to their population, simply because they've got such large income flows that their budgets aren't being pressured. So, there's no danger of Mr Chavez suddenly saying "I've got to tax my people a lot more on the gasoline front because I want more supply to send to Houston." He's not going to do it; it's as simple as that. So, about ten million barrels a day of world consumption is subject to significant subsidy and hence, they are unaffected by high prices. It's of no interest to them, and then there's another ten million barrels per day that has limited subsidy, usually in specific sectors like kerosene for heating. So, in effect, that blunts any price effect, if you like, in the world. It also has the effect that it provides rather less for us, to put it crudely, so what I've done here is; I've simply added, at a quite low assumption, I've seen much higher numbers than that, and said that the oil producers' consumption is growing at four percent a year, whereas the rest of the world is very much lower than that, and I've put that in simply by jacking this line up, to make it straight forward. Then we find that the amount of oil we've got available, to meet demand in the rest of the world, is more or less what we

had last year going forward and then, as I say, you get the move to Peak Oil to the end of 2010.

So, if this analysis is robust, which I think it is, we can be pretty sure that prices are going to have to stay very firm. That we are starting to become constrained. That those CIBC numbers no longer look sort of wild; they look a reasonable assessment of what's happening, and that is before we hit the discontinuity. So, almost there.

There are some wild cards; I don't know how to assess those, I don't think anyone else knows how to assess those. Iran, quite literally, could be producing more in a few years or it can be producing a lot less. The Saudis are clearly spending enormous sums of money; they used to, even three years ago, only have about thirty or fifty rigs operating at any one time. They've got that up to one hundred and twenty; they're planning to take it up to one hundred and forty. This is hardly the action of a country where everything is going really well, so they have clear problems in maintaining that capacity. So, suddenly, what should be a bedrock predictable supply source, we're getting a few question marks creeping in as to whether they will be able to do what we're currently anticipating.

Finally, just to show there are other opinions; CERA, the American consultancy that I mentioned, has a very optimistic assessment that's just come out, in which they believe that we can get up to one hundred and ten million barrels a day by 2015. The IEA has just brought out a medium term report which rather eccentrically just goes to 2011, or maybe not so eccentrically, and that's my best projection of what's going to happen; that we're going to get the peak around 2010 to 2011 and it's then going to gently tip down.

To get to this very high number, CERA need to explain to us why they are assuming more capacity than the Russians themselves assume. Why their numbers for OPEC capacity are higher at both a field level and a country level than OPEC is prepared to claim. They've certainly got the highest number I've seen anywhere for Canadian tar sands production. I don't know any Canadians that would subscribe to that number, and the final thing that discomforts one is they've got a field called Urugua, which is a smallish field off Brazil, coming on stream in 2009. Now, the Petrol <inaudible> House Magazine, not normally noted for its

pessimism, doesn't believe Uruguay will be on stream before 2011, which seems a much more reasonable date, so I think, if we are to believe the reassurance that CERA is offering us, we need to ask some key questions of them, otherwise we join the IEA, again not normally noted for its pessimism, and myself, in predicting that sort of profile.

So, what can we do? Well, literally, those are the mitigations, or those are the key mitigations, but the sooner you start, the better is all I can usefully say, and Robert Hirsch's second report, the one he did with Dr Bezdek, which in effect said "What can we do?" In terms of both global and US mitigation, and that was in terms of a crash program and money no object, and the two key learnings from that; one, it builds up to a quite decent number twenty years out, but nothing much happens for the first four years as you're investing, and then it just builds up gently but steadily.

I think I've more or less over-run my time. I've one...those are my conclusions, if you like, but really, it is a short period of time we're talking about and we aren't going to get any price alleviation except the most temporary sort. That I sometimes put in, and that sometimes amuses people and sometimes doesn't.

That's me, and you have a pretty active ASPO Australia and Bruce Robinson is the convener for that, and they're starting to do some good work, informing you of what's going on.

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