

Envisioning a sustainable Ireland
from an
energy availability perspective

**A report to the
Environmental Protection Agency**

Contents

Introduction

Chapter 1: Why energy prices are likely to rise in relation to labour.

Chapter 2: Using scenarios to explore responses to restricted fossil energy supplies.

Chapter 3: The use of the ECCO model to assess the scenarios.

Chapter 4: The effects of much higher energy prices on sectors of the Irish economy.

- a) Energy services:
- b) Transport, distribution and tourism.
- c) Agriculture.
- d) Manufacturing.
- e) The construction sector.

Chapter 5: Effects of these changes on the projections from the ECCO model.

Chapter 6: Effects of higher real energy prices on the consumer.

Chapter 7: Conclusions

Appendices

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Introduction

It is increasingly accepted that, even if no restrictions are placed on fossil fuel use in response to the threat of climate change, the total amount of energy available to the world economy from oil and gas production will almost certainly peak within the next twenty-five years and perhaps within the next ten. This peak and the decline that follows this will have profound implications for the Irish economy and society. No aspect of life will be unchanged. Despite this, however, very little thinking about the nature and extent of the changes has been carried out in Ireland or abroad. Instead, government and the private sector are still making investments on the assumption that 'business as usual' - that is, continuing increases in energy consumption - will be possible. The proposal for another terminal at Dublin Airport is an example of this type of thinking. However, if the increased energy supply assumption turns out to be incorrect, a lot of the investments being made now or planned for the next few years will turn out to be completely unsuited for the energy-scarce world in which they will have to generate a return.

This project therefore set out to get public servants and business people to compare the conventional business-as-usual scenario with three other scenarios which, taken together, were intended to bound the range of possibilities within which Ireland's energy future is likely to fall - provided, of course, that a major war is avoided, that there is no catastrophic weather event which dramatically alters the global response to climate change, and that a plague like bird flu does not kill a large proportion of humanity.

We invited decision makers to one or other of two one-day seminars, both in Dublin at which we explained the grounds for believing that energy supplies might be restricted in future and that this would mean that they became much more costly. The four scenarios were then explained. These differed only in the timing of the peak in energy supplies and the way the government and the international community responded to the peak. After that, we divided the participants into groups of six, each with a facilitator, and invited them to think through the consequences of each scenario by imagining that they were journalists on a trade magazine for a particular

sector of the economy in the year 2015, trying to interest their editor, the facilitator, in a story dealing with changes that they expected to have happened under that scenario at that time. The approach was deliberately light-hearted as this enabled the possibilities to be considered far more easily.

The headlines of the articles proposed were posted on a website, www.energyscenariosireland.com we set up for the project as a way of allowing more people to inform themselves about the possibilities and to comment on them. The website stimulated a lot of online discussion and won an honourable mention in an international competition (see www.beyondpeak.com/scenarios/ireland1.html).

Some decisionmakers displayed extreme reluctance to consider how their businesses would be affected if energy prices rose massively in real terms. Indeed, the greater the proportion of the costs of their business that energy purchases made up, the greater reluctance there seemed to be to explore the possible effects. When we wrote to Aer Lingus and Ryanair to invite them to send someone to the seminar, Michael O'Leary replied personally by return of post saying that his company was "too busy growing the airline" to spare anyone to attend. Aer Lingus did not reply at all, in spite of several attempts to follow up the letter by speaking to someone with a strategic planning function.

In two other meetings, one in Galway, the other in Waterford, we got consumers to think about how they would react to a radically different energy future. At each meeting the film *The End of Suburbia*, which deals with the consequences of a decline in oil production, was shown. Afterwards, we used a series of slides to explain to the audience that they should expect the 90% fall in the real price of energy since 1920 to be partially reversed and that this would make everything they bought more expensive in relation to the amount they earned. We gave them a form listing hypothetical energy-cost related price increases for the major categories of consumer goods and services and the proportion of their income that their purchases of these made up. How would they try to balance their budgets in the new price regime? A total of 68 forms were completed and the results of their analysis are given in Chapter 6. They show that ordinary people (if people prepared to attend the showing of a film on peak oil can be considered ordinary) are prepared to be very

flexible, a finding in sharp contrast to the reaction we got from most of the decisionmakers.



Illustration 1: How oil prices have soared since this project was conceived in 2004. The volatility of the prices has increased considerably, too. Source: Oil-price.net

Besides the seminars and the two meetings with consumers, we spoke about the project at several conferences and had face-to-face meetings with people from key organisations like the Construction Industry Federation, the Irish Road Haulage Federation and the Irish Farmers' Association. A full list the people to whom we spoke and the events at which we made presentations in the course of the study can be found in the appendices. The information we gleaned from these meetings was coupled with extensive desk research to develop the projections we make under two of the scenarios for each major sector of the Irish economy in Chapter 4. These projections were discussed with people from the sectors concerned before being used as the basis of a final run of ECCO, our model of energy and material flows in the Irish economy. The main conclusions from our work are listed in the box opposite.

Does the business as usual option still exist?

When we first submitted our research proposal to the EPA in May 2004, oil was within the \$20 - \$32 range that it had traded since 1999 and we thought we would be pushing the limits of our credibility if the project set

out to examine the effects of its price increasing by a factor of ten over, say, the next twenty-five years. We nevertheless decided that it would do so. Today, oil is twice the price it was then, and it has been as high as 2.5 times its May 2004 level. In other words, the price that would have represented a tenfold rise when we started out now only amounts to a fivefold rise from the current level and a fourfold rise from the levels already seen. More significantly, no-one talks any longer of an "oil price spike" (in other words, a rapid rise followed quickly by an equally rapid fall) in the way that they did when prices first began to move up strongly. A widespread view among market commentators is that current (end 2006) oil prices of around \$60 a barrel are likely to be maintained and could well move back up to \$70 a barrel during 2007.

The major international energy companies are investing heavily on the assumption that the higher prices will at least be maintained with the result that headlines like "Nikkei slips as lower oil price hits energy stocks" (Reuters, November 17, 2006) are common when energy prices slip back and reduce the profits that investors expect them to make from their new projects.

The effects of the price rise have already been huge, for both countries and companies. In December 2005, Andrew N. Liveris, the chief executive of the Dow Chemical company was quoted in *The New York Times* as saying "Three years ago, Dow's annual bill for energy and hydrocarbon raw materials was \$8 billion. Today that number approaches \$22 billion. Put another way, in 2002, energy and feedstocks represented 29 percent of our costs. Today they are 50 percent." Liveris went on to stress that these changes were the consequence of the United States' failure to anticipate what was happening in the energy market. "The high price of natural gas accounts for most of the rise. And [that] is a direct consequence of the failed energy policies of the 90's, which encouraged the overbuilding of power stations without increasing the availability of gas."

For countries, the high prices have brought big changes in the global pecking order. In 1999, before the upward trend in prices began, the purchase of oil required 1.37% of global GDP. In 2006, although the final figures are not in yet, it will have required about 4.5% of GDP. Most of this extra 3% of world income has gone to the oil producing countries rather than the major oil companies. One of the consequences has been to turn Russia from being an economic basket case which defaulted on its debts its

debts in 1998 to a country which has returned to being a formidable international power, with an investment-grade rating on its debts and a large current account surplus.

Even the International Energy Agency has changed its stance, warning in November 2006 that a peak in the oil production in non-OPEC countries would be reached in 5-7 years and saying that very much greater levels of investment were going to be required if the growing world demand was to be met. Despite the higher prices, the world's energy industry was not building enough new oil and gas capacity to ensure secure supplies, it said. Almost all the increased investment went to covering the massive jump in costs, rather than to producing new sources of oil and gas. "Expressed in cost inflation-adjusted terms, investment in 2005 was only 5 per cent above that in 2000," it said in its report, *World Energy Outlook 2006*. Much of this investment would have to be in OPEC countries which would need to almost double their current production.

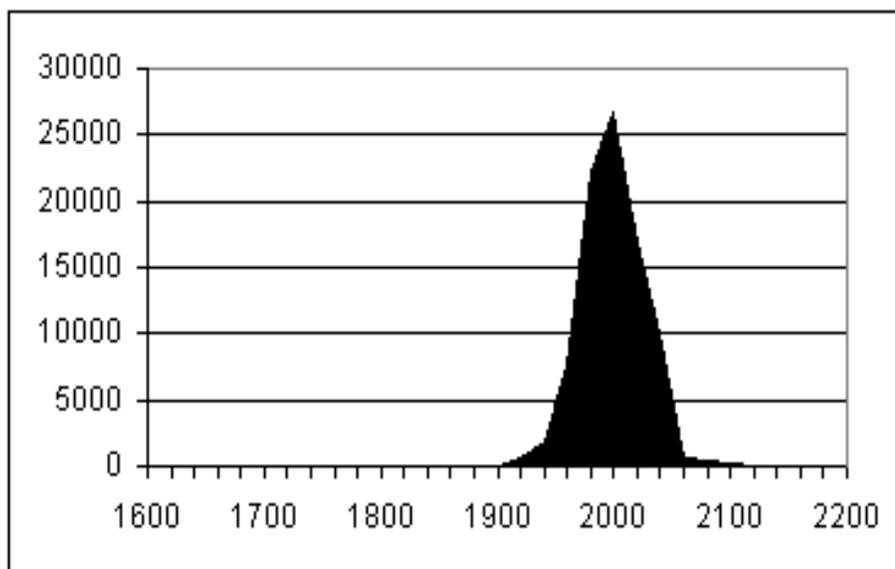
In a sense then, the path that was thought of as business as usual when we began our study two years ago no longer exists. This was confirmed in September 2006 when the Finfacts Ireland website commented that "the peak oil theory" had become "the conventional wisdom." That verdict was perhaps a little premature. In our view, all that has happened is that the idea that oil supplies are going to be tight for the foreseeable future has begun to sink in and companies are taking the doubling of their energy costs into consideration when making their investment decisions. The real internalisation of what peak oil means has yet to begin and cannot be said to have been achieved until decisionmakers and households broadly accept these six points:

1. That the amount of fossil energy available to each person on the planet is already levelling off and that it will begin to fall when the global supplies of, first, oil and then gas begin to decline because of resource depletion. Productivity per capital is likely to be affected.
2. That, as a result, while some sectors of the economy will still grow, most will decline and average incomes will shrink in terms of what they can buy.
3. That, to survive in what may be a shrinking market, businesses should now pay more attention to minimising their energy costs than their wages bill. This could mean re-skilling their workforces, paying them more and using less capital equipment. Equally,

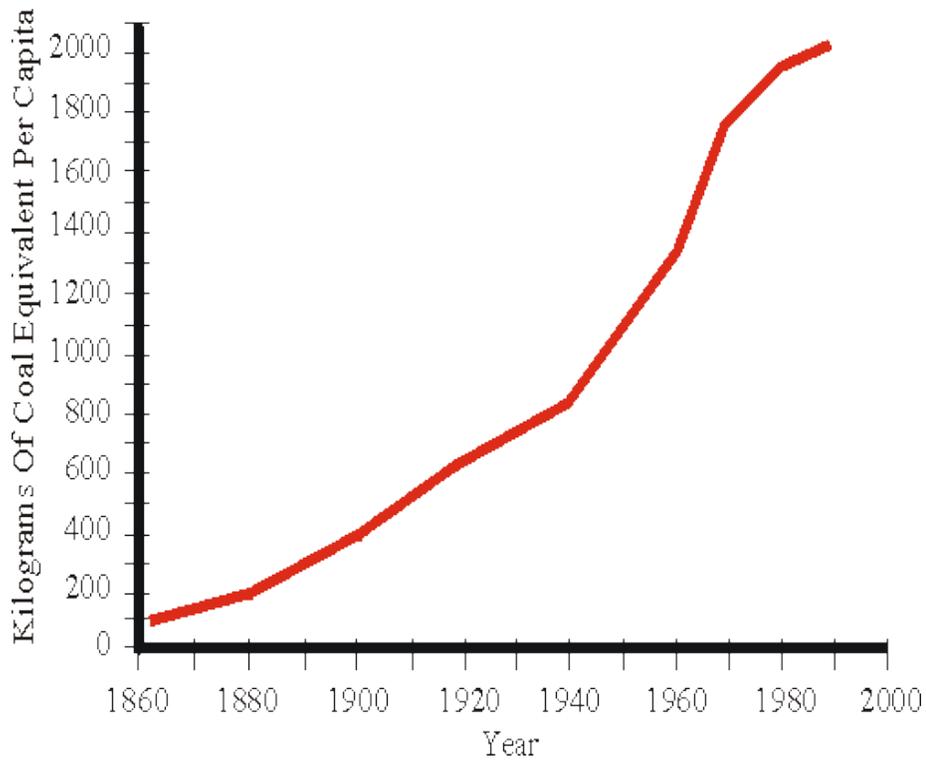
- families should seek to cut their energy costs rather than seeking higher incomes to pay for their energy purchases.
4. That the cost of some modes of transport will rise significantly. This will make decisions about where and on what scale to produce, and where to live in relation to one's work, vital for financial health.
 5. That the throw-away economy will die shortly and that, from now on, goods should be bought on the basis of their long-life and repairability
 6. That the control of energy, rather than the control of money, will be the new source of political and economy power. Countries or communities able to offer secure energy supplies will have a big competitive advantage.

Only then will it be possible to say that Business as Usual has really been abandoned and that the second of our scenarios, Enlightened Transition, has taken its place.

***The size of the problem I:** This graph shows how world oil consumption rose in the last century and can be expected to fall during the current one. In historical terms, the use of oil as an energy source is nothing more than a blip, but one which took human development off on an unsustainable course.*



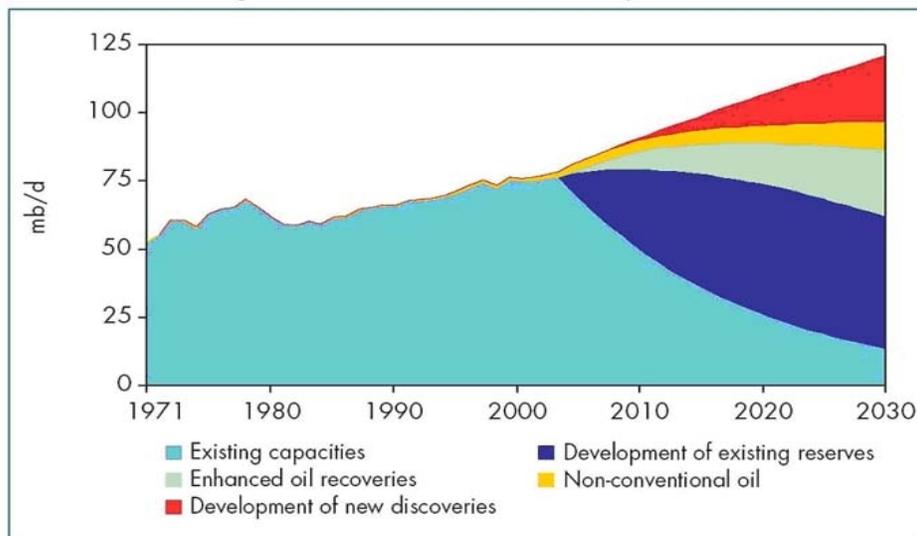
The size of the problem II: *The graph shows how energy use per person around the world has risen over the past 150 years but that the level of use is showing signs of levelling off. It is this increase in energy use that has boosted human productivity and incomes. However, the depletion of oil and gas almost certainly means that the level of energy use is about to fall.*



Chapter 1: Why energy prices are likely to rise in relation to labour

A. The availability of oil

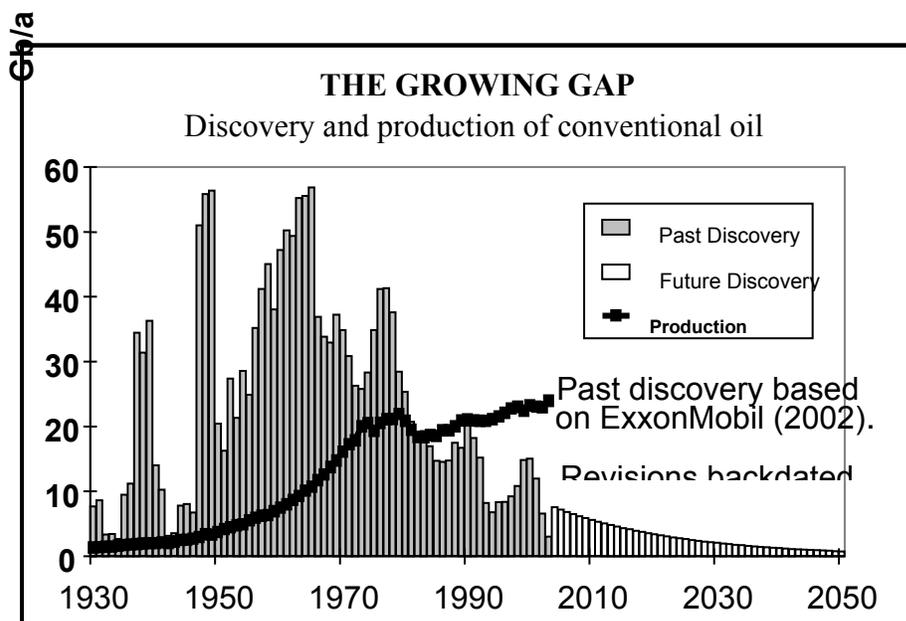
There are two schools of thought about future supplies of oil. One school is dominated by economists who regard oil as just another commodity and who believe that the supply of a commodity will increase if its price rises because the higher price means that more resources can be profitably devoted to its production. If sufficient investments (around \$3 trillion) are made, these economists say, world oil production will increase for at least another 25 years. "We might be running low on \$20 oil, but for \$60 we have adequate oil supplies for decades to come" says Professor Kenneth Rogoff of Harvard and a former chief economist at the IMF.



Graph 1: Where the International Energy Agency thinks the world's oil will come from in future. The IEA emphasises that it will take massive investments to enable output to continue to climb and that high prices will be needed to attract capital on the required scale.

This view is expressed most clearly by the International Energy Agency. Graph 1, is taken from the IEA's *World Energy Output 2004* and shows that the IEA expects most of the increase in production to come from developments to existing oil fields. These developments involve finding that there is more oil in the fields than is currently known to be the case - the dark blue area - and

developing technologies which enable a greater proportion of the oil in a field to be extracted than is possible at present, the light blue zone. Very little reliance is placed on new oil discoveries, the red area. This is just as well, since far less oil is being discovered each year at present than is being produced, as shown in Graph 2. Chevron puts the discovery rate at half the production rate in its press advertisements while others say the rate is a quarter or even a sixth. What is certain is that in 2004, the world produced 30.5 billion barrels of oil but discovered only 7.5 billion barrels to replace it. "It is true that the big firms are struggling to replace reserves" writes *The Economist*, (22.04.06) which has consistently taken the IEA's line. "But that does not mean the world is running out of oil, just that they do not have access to the vast deposits of cheap and easy oil left in Russia and members of OPEC".



Graph 2. Oil is currently being found at perhaps a quarter of the rate at which it is being used.

In fact, no-one is saying that the world is running out of oil. All they are questioning is whether supplies will be able to keep up with rising global demand. There is still plenty of oil in the ground but, despite what the economists say, oil is not a commodity like any other. It is a source of energy and, if it takes more energy to extract and refine it than the oil itself delivers, that process will never be profitable, no matter how high the price rises. As increasingly difficult oil sources have to be tapped, the net energy gain - the energy return on energy invested (EROEI) ratio - declines. At some point,

throwing more resources – that is to say, energy – into the effort to produce becomes pointless. When that happens, world oil output will cease to increase, stay on a plateau for a few years and then fall.

Oilmen know this and more and more of them are saying that the economists are wrong to project a rising oil output for the next 25 years. Initially, it was retired petro-geologists - people like Dr. Colin Campbell – who had the freedom to speak and used it to attempt to point this out, but top oil company executives have been saying so too with increasing frequency.

2. “We’ve embarked on the beginning of the last days of the age of oil,” Mike Bowlin, Chairman of ARCO, in February 1999.
3. “We’ve run out of good projects. This is not a money issue...if these oil companies had fantastic projects, they’d be out there [developing new fields].” Matt Simmons, head of the oil investment bank Simmons and Company International and a former adviser to President Bush, November 2004.
4. “My view is that “easy” oil has probably passed its peak” Jeroen van der Veer, the Chief Executive of Royal Dutch Shell said in January 2006. By “easy” oil he meant oil requiring little investment in complex rigs and infrastructure (and thus little energy use) to extract.

The oil companies' problem is that enough new oil production has to come on-line to cover both the growth in world demand of at least 2 million barrels a day each year and the decline in production from existing fields of over 4 million barrels a day each year. “That’s like a whole new Saudi Arabia every couple of years,” Sadad al-Husseini, the retired head of exploration and production at the Saudi national oil company, Aramco, said in August 2005. “It’s not sustainable.”

The increasing difficulty in producing oil led to a direct attack on the IEA projections by Christophe de Margerie, head of exploration for the French oil company Total in April 2006 in an interview¹ with *The Times* of London. The IEA predicts in its *World Energy Outlook* graph (Graph 1) that the global supply of crude oil will reach 121 million barrels per day by 2030. “Numbers like 120 million barrels per day will never be reached, never,” de Margerie said. The world was mistakenly focusing on oil reserves when the problem was the capacity to produce oil. The IEA had failed to consider the speed at which new projects could be brought on stream. The resources were simply not available. “Take Qatar. How many projects can you have at the same time? You have more than 100,000 people working on sites. It’s a big city of contractors. Now they have the problem of having to build a new power plant to supply a city of contractors.”

Chris Skrebowski, the editor of the *Petroleum Review* takes this further. He says that during 2006, 40% of the world's oil was being produced by countries including the US, Britain, Norway and Venezuela, whose output was already declining year by year and a further 10% was coming from countries such as Mexico, whose output was about to begin to fall. The growing shortfall from these countries, plus the increases required to meet the rising global demand, could only be met from fields in the Middle East and Russia, but he did not think this could happen. "There are not enough large-scale projects in the development pipeline right now to offset declining production in mature oil fields and to meet global demand growth beyond 2007" he says.

Even the IEA has started admitting that there are short- and medium-term problems. "The world is facing strong crude and product prices until around 2010," its Executive Director, Claude Mandil, said² in May 2006. "Probably, we will have to live for the next four or five years with very tight capacities, tight markets and strong prices," In November 2006 he repeated his warning in even stronger terms saying that the world's current oil supply and climate situation "may mean skyrocketing prices or more frequent blackouts; can mean more supply disruptions, more meteorological catastrophes - or all these at the same time".

Many experts expect that total world oil production will begin to fall before 2010. Table 1 is a summary of the various predictions that have been made.

Table 1. Projections for the peak in world oil production		
Date	Expert	Background & Source
2006-2007	Bakhtari, A.M.S.	Iranian oil executive: Ref. 1
2007-2009	Simmons, M.R.	Investment banker: Ref 2.
After 2007	Skrebowski, C.	Petroleum journal editor: Ref 3
Before 2009	Deffeyes, K.S.	Oil company geologist (ret.): Ref. 4
Before 2010	Goodstein, D.	Vice Provost, Cal Tech: Ref. 5
Around 2010	Campbell, C.J.	Oil company geologist (ret.): Ref. 6
After 2010	World Energy Council	Non-Government Org: Ref. 7
2010-2020	Laherrere, J.	Oil company geologist (ret.): Ref 8.
2016	Energy Information Agency	US govt. dept. Ref. 9.
After 2020	Cambridge Energy Research	US energy consultants: Ref. 10
2025 or later	Shell	Major oil company: Ref.11
No peak	Lynch, M.C.	Energy economist: Ref. 12

1. Bakhtiari, A.M.S. "World Oil Production Capacity Model Suggests Output Peak by 2006-07." *Oil and Gas Journal*, April 26, 2004.
2. Simmons, M.R. Association for the Study of Peak Oil (ASPO) workshop. May 26, 2003.
3. Skrebowski, C. "Oil Field Mega Projects - 2004." *Petroleum Review*. January 2004.
4. Deffeyes, K.S. *Hubbert's Peak-The Impending World Oil Shortage*. Princeton University Press. 2003.
5. Goodstein, D. *Out of Gas - The End of the Age of Oil*. W.W. Norton. 2004
6. Campbell, C.J. "Industry Urged to Watch for Regular Oil Production Peaks, Depletion Signals." *Oil and Gas Journal* July 14, 2003.
7. *Drivers of the Energy Scene*. World Energy Council. 2003.
8. Laherrere, J. Seminar Center of Energy Conversion. Zurich. May 7, 2003
9. DOE EIA. "Long Term World Oil Supply." April 18, 2000.
10. Jackson, P. et al. "Triple Witching Hour for Oil Arrives Early in 2004 - But, As Yet, No Real Witches." *CERA Alert*. April 7, 2004.
11. Davis, G. "Meeting Future Energy Needs." *The Bridge*. National Academies Press. Summer 2003.
12. Lynch, M.C. "Petroleum Resources Pessimism Debunked in Hubbert Model and Hubbert Modellers' Assessment." *Oil and Gas Journal*, July 14, 2003.

Three broad oil supply/oil price outcomes must therefore be considered:

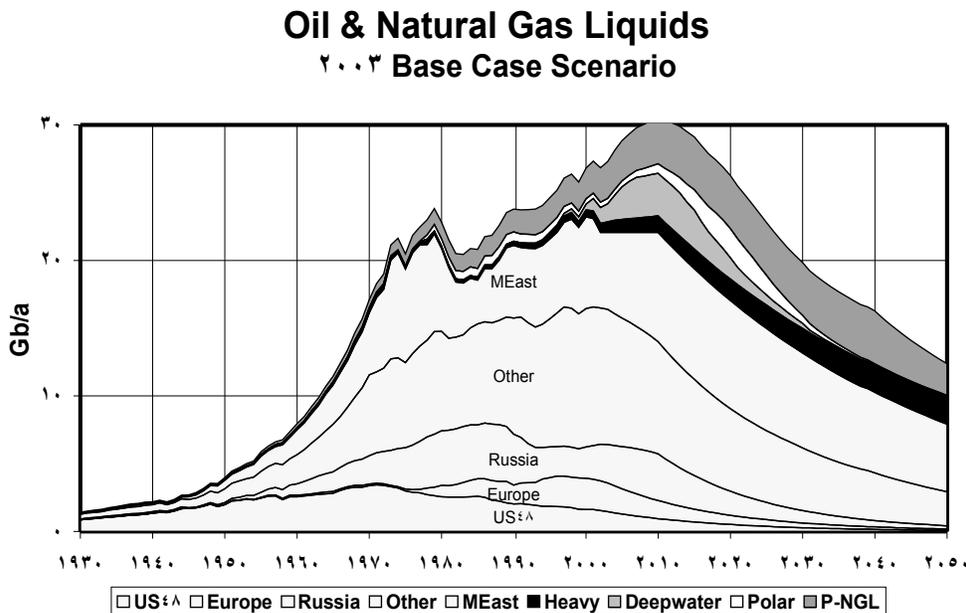
7. The oil men are right and oil output in 2006 turns out to be close to the peak in world production and deliveries begin to fall within the next few years. Prices therefore go very high as users compete to secure supplies.
8. The economists are right and world oil output continues to increase over the next 25 years. However, the oil is much more expensive in real terms

than in the 1990s because of the need to attract huge amounts of capital and to exploit increasingly difficult sources.

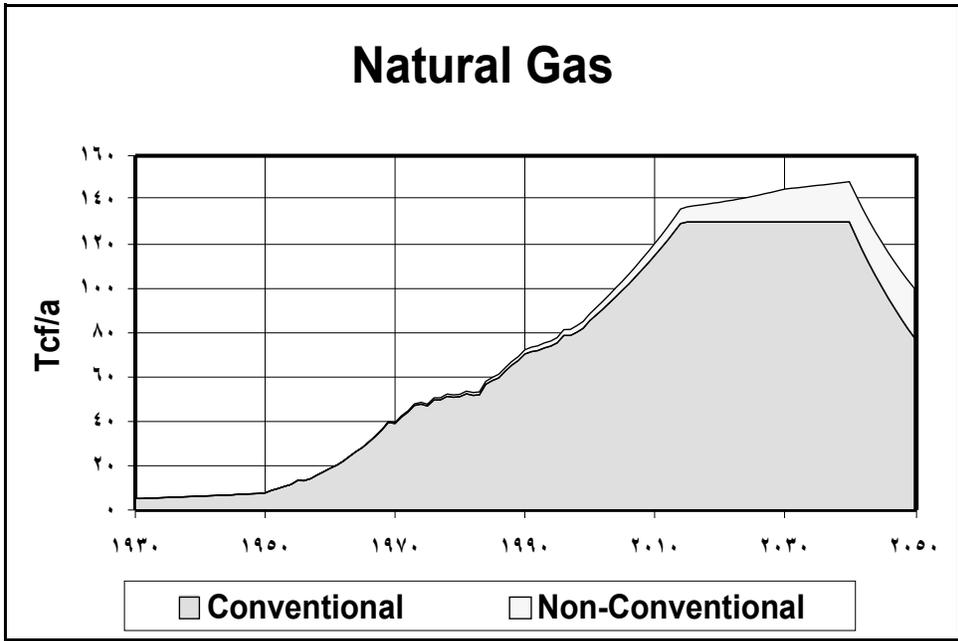
9. High oil prices arising from either (1) or (2) push the world into a depression. The demand for oil drops and so does its price.

1. The oilmen are right.

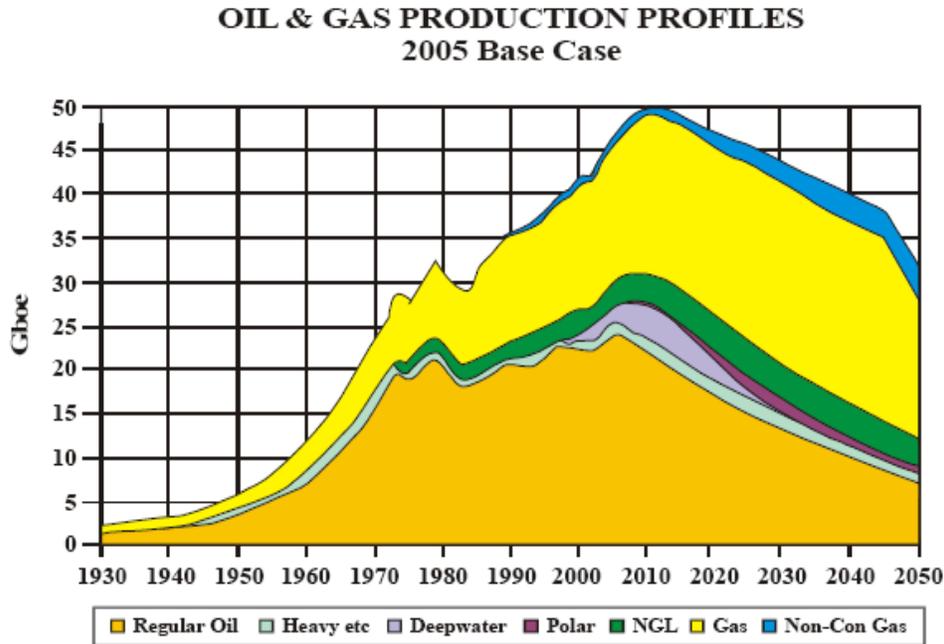
In this case, the world's production of oil is likely to fall at between 4% and 6% a year, as shown in Graph 3. There are limited prospects for replacing oil with natural gas because supplies of that, too, are expected to peak in the near future. Graph 4 shows projections for global gas supplies and Graph 5 shows the total amount of energy that can be expected to be available from the two fuels together. Under the oilmen's scenario, this decline can be expected to begin within the next ten years. Coal production will be increased in an attempt to compensate but the energy return on energy invested is poor, particularly if the flue gases are scrubbed to remove sulphur dioxide and especially so if the carbon dioxide is sequestered. Some coal will be turned into liquid fuels for transport using variants of the SASOL process. This, again, involves



Graph 3: The Association for the Study of Peak Oil expects the world's production of oil to peak within the next few years and then decline quite rapidly



Graph 4. Although there is a lot of natural gas left, the Association for the Study of Peak Oil does not expect output to continue to rise after about 2013.



Graph 5. The total amount of energy that the world will be able to get from oil and natural gas could start to fall within 5-10 years.

energy use, energy loss and expense. It seems highly unlikely that alternative energy sources can be developed rapidly to replace oil and gas if supplies decline as rapidly as expected by the Association for the Study of Peak Oil. The strength of the world economy and availability of the alternative fuels is likely to determine how high oil prices rise.

2. The economists are right.

Two possibilities arise here: one is that oil output rises at the 1.6% per annum forecast by the IEA, rising from 77 million barrels a day in 2002 to 121 million in 2030, and that this matches the growth in global demand and that, consequently, the rate at which prices increase is modest. The other possibility is that the 1.6% rate is inadequate to meet global demand and that oil prices go very high and world growth slows down.

In either case, Ireland would be able to secure all the oil it needed – the only thing which differs between the two possibilities is the price at which oil would be available. However, because of the EU's efforts to limit climate change with its Emissions Trading System, Ireland would also have to obtain the emissions permits to use the oil and it would be competing with other EU countries for these. It might turn out that, if the oil price was low, the emissions permit price would be high and *vice versa*, so that there could be little difference between the two cases – the effective fossil fuel price would be high whatever happened. This would be a good outcome because it would preserve the incentive for the development of non-fossil energy sources.

3. High oil prices push the world economy into a recession

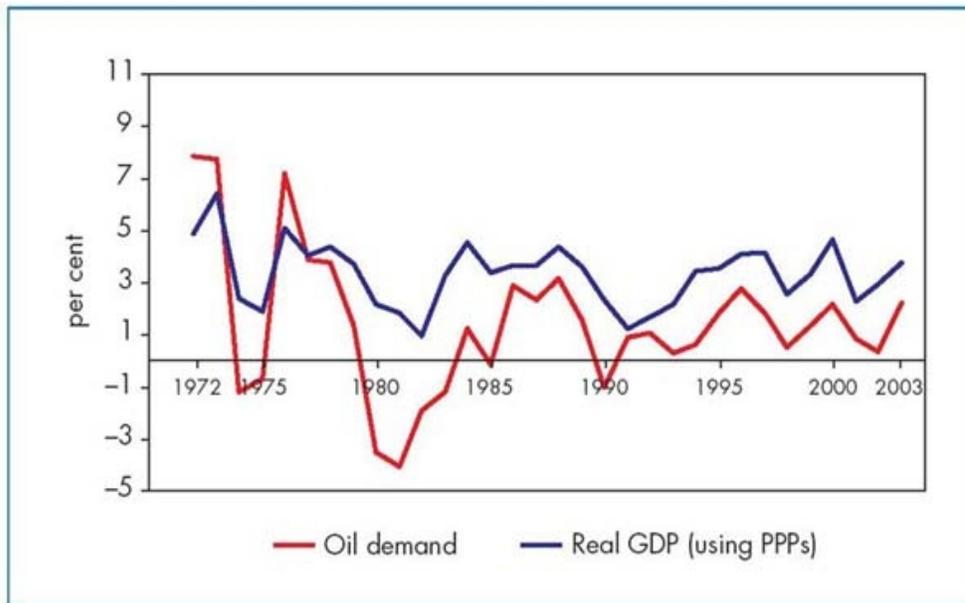
This is probably the most likely outcome to emerge. It would not be the oil prices themselves which caused the recession but the efforts of the world's central banks to limit the inflation that the higher energy costs are already causing. Research³ in America indicates that for every \$10 a barrel rise, the US growth rate falls by 0.4% for about four months. This drop happens because consumers who are spending more for oil have less to spend on other things. After that, however, the economy recovers rapidly as firms invest in new opportunities such as supplying equipment for renewable energy projects and consumers invest in improving the energy-efficiency of their homes. After 18 months the higher energy prices actually boost the US growth rate by 0.1%, an effect which lasts for another year and a half. It would therefore take a very big, sudden increase in energy prices to send the US and the world economy into a recession.

The inflation which causes the central banks to act could be caused, at least in part, by the type of boost that higher energy prices give to an economy. Counter-intuitively, the investments in energy-saving projects and renewable energy systems made in response to higher energy prices actually increase energy demand. This is because investment projects of any sort are more energy-intensive, because of the energy required to make and instal the equipment they require, than, say, typical consumer expenditure such as a meal in a restaurant. In other words, higher energy prices can increase the demand for energy.

This means that a positive feed-back loop could develop, with increased energy prices leading to increased energy-related investment, leading to a further increase in energy prices... and so on. The world's central banks obviously need to moderate this effect but, if in doing so, they use too heavy a hand when raising interest rates, they could increase the amount that consumers have to pay on their mortgages and other borrowings at the same time that the higher energy prices are forcing them to cut their expenditure in other areas. This would reduce consumer demand and, if the drop was significant, so many firms might cancel investment projects that a downward recessionary spiral developed, lessening the demand for oil and bringing its price down. High and widespread unemployment would then develop which could persist for several years since every nation would be affected and no one of them would be able to act as the 'engine of global growth'. The continuing low fossil energy prices during this period, coupled with the lack of confidence and low energy demand would destroy the incentive to invest in renewable energy and energy saving projects. The overall effect would be that the world continued to deplete its fossil fuel reserves without building renewable systems to replace them. We feel that there is such a serious risk of this happening that we made it the basis of the Enforced Localisation scenario described in the next chapter.

The effects of the peaks in the supply of oil and gas

The timing of the peak in world oil production is crucial because it will mark a major change in the way the world economy operates. There is a very close connection between the rate of increase in world oil use and the total world production of all goods and services as Graph 6 shows. Accordingly, unless other sources of energy can be found to replace oil and gas or the efficiency with which the two fuels are used can be increased more rapidly than their output declines, or a combination of the two, world output will decline once the joint oil-and-gas peak is passed.



Graph 6: The close relationship between oil use and world output.
Source: International Energy Agency.

Graph 5 indicates that a 10% fall in the amount of energy available from oil and gas can be expected within 15 or 16 years of the combined peak being reached. It is by no means impossible that, spurred by higher prices, gains in the efficiency with which those two fuels are used will be enough to cancel out this decline. However, will any extra efficiency gains, plus whatever increases we can expect in the supply of nuclear, coal and renewable energy, be enough to keep the global economy growing at the pace it did in, say the 1990s, a period in which the amount of energy delivered to the world economy by oil and gas together rose by 20%? In our view, the answer is “no” and the rate at which the world economy will grow will fall.

We also have to ask what types of energy the substitutes will provide. As we show in Chapter 4, 50% of the world's oil is used for transport, and 81% of that is used by road vehicles. We also show that renewable biomass sources of ethanol and diesel will not be adequate to replace more than a fraction of the fossil vehicle fuels now being used. Because petrol and diesel have such a high energy density, and are therefore very convenient, and because no substitutes are in sight for aviation fuel, we can expect the price of vehicle fuels to rise in relation to other forms of energy such as electricity which can be produced from a wider range of sources. This will also affect the rate of growth as a lot of recent growth

has been generated by reaping the economies of scale by producing large amounts using specialist equipment in a few locations and then distributing the output around the world. In short, we expect the rise in transport costs, particularly by air and road, to cancel out many economies of scale and for industrial production to become more localised and labour-intensive.

As well as the distribution of industry, the distribution of the incomes generated by the global economy will also change, with far greater amounts going to energy producers. As a result, the real value of the average wage is likely to fall because any increases in income from the limited amount of growth which it might be possible to generate from the restricted energy supply are likely to be outweighed by the price rises caused by the higher energy costs. As energy prices rise, increasing amounts of purchasing power will flow out of Ireland to the sources of our fossil fuel supplies, lessening the amount that people here can invest or spend.

In order to limit this flow, it is not inconceivable that the governments of fuel importing countries will set up what would be equivalent to a buyers' cartel, to negotiate with the sellers' cartel, OPEC, for supplies. The buyers' cartel would agree a price and a quantity each year with the suppliers, and then share out the amount it had purchased amongst its members. We have proposed a way of doing that in our Fair Shares scenario. Such an arrangement would stabilise the world economy and could thus be advantageous to both buyers and sellers. After all, it is not in OPEC's interests for oil and gas prices to rise so high on a temporary basis that the world economy went into a depression, since a depression would mean that its prices and net income fell to very low levels, possibly for several years.

There are moral arguments for this type of arrangement too. Floyd Landis, who won the 2006 Tour de France averaged 280 watts over the five hours of one of his winning rides and has averaged 320 for six hours in training. In other words, an exceptionally fit man can produce something over a kilowatt hour of useful work in a day. However, a more generally applicable figure is that a strong person can produce 75 watts per hour⁴, which gives 3 kWh in a 40-hour working week. At present electrical costs of 13 cents/kWh, a week of hard human labour would therefore be worth about 45 cents, or about one cent per hour. A litre of petrol has an energy content of 8.9 kWh, and is therefore equivalent to three weeks' manual work.

The conclusion from this is that someone with access to fossil energy will be able to boost their productivity to such an extent that they will always be able to out-compete someone relying on their labour alone. As a result, the person using energy will be able to afford to buy further energy supplies whereas the

poorer person will not. As a result, the distribution of energy around the world will become even more polarised than it is at present, and with it the distribution of wealth. A rationing system to share the available fossil fuel would offer the possibility of avoiding the backlash that such a polarisation would create.

In the longer term, as the world moves further down the oil and gas production curve, the volume of production that will be possible globally is almost certain to fall as the fossil energy subsidy it has been enjoying is taken away. In short, the era of rapid economic growth will end. The world will return to the situation in which a 10% increase in total incomes in a century is good, rather than 10% in a single year.

Conclusions:

The period of rapid growth in the world economy made possible by the use of fossil fuel is coming to an end. We are now about to enter a period of rapid change in which the winners will be those countries and companies which adapt most quickly to the new situation, investing now in projects that will stand them in good stead in a world in which energy of any sort is scarce and expensive. Such investments will embody energy bought at today's prices, and will increase in value as energy costs rise. The early investors in wind farms have done very well since electricity prices went up.

Many sectors of the economy will become unprofitable and contract during this transition period and it is not clear if the profits and additional incomes that will be generated by the expanding sectors will outweigh those losses. As a result, unemployment might increase and the overall economy decline.

¹ <http://business.timesonline.co.uk/article/0,,13130-2124287,00.html> (April 8th, 2006)

² <http://www.platts.com/Oil/News/8423016.xml?p=Oil/News%82%22=Oil&src=energybulletin>

³ Ben S. Bernake et al, "Oil shocks and Aggregate Macroeconomic Behavior: the Role of Monetary Policy, a reply" *Journal of Money, Credit and Banking*, Vol. 36, No. 2, 2004.

⁴ *The End of Fossil Energy: And a Plan for Sustainability*, John Howe, McIntire Publishing, September, 2004)