after oil

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The extraordinary prosperity of the twentieth century was built on cheap oil and gas. When they are no longer either cheap nor reliably available, the economic consequences will be far greater than can easily be imagined.

Beneath the seabed off the coast of Saudi Arabia, there is an oil field called Manifa. It is a giant, and its riches are almost untapped.[1] There is, however, a snag. Its oil is heavy with vanadium and hydrogen sulphide, making it virtually unusable. One day, the technology may be in place to extract and dispose of these contaminants, but it will not be for some time and when, or if, it does happen, it will do no more than slightly reduce the rate at which world oil supplies slip away towards depletion. However, even this field has advantages relative to the massive reserves of oil which Middle East suppliers are said to hold ready to keep oil prices low and secure the future of civilisation. Unlike those fantasy fields, Manifa actually exists.

For the last twenty five years, there has been a tacit consensus that oil depletion has almost no place on the environmental agenda. This is partly a reaction to the criticism of the Club of Rome's (1972) study, The Limits to Growth, which drew attention to the existence of limits to the oil resource [2]. The study was revisited and ably defended [3], but the weight of criticism was crushing, and environmental policy turned instead to sustainable development. The question of resources - oil included - came to be regarded as an embarrassing phase in the environmental movement's early days [4].

But now, it is back with a vengeance. In region after region, the story is of ageing oilfields, of the wrong sort of oil, of nitrogen being pumped into wells to keep up the flow, of exploration turning to unpromising areas such as West-of-Greenland. The UK's North Sea oil is past its peak now, as are the giant fields in Alaska, the

former Soviet Union, Mexico, Venezuela and Norway are all past their peak. The United States' own oil supplies have been declining since 1970 and now account for less than half its needs. There is a possibility of some significant finds off the coast of West Africa, but their development is still years away, and they are not on a scale capable of making a difference. The only producers who still possess an oil resource which may be capable of keeping oil flowing into the world market at a roughly constant level are the Middle East OPEC Five - Saudi Arabia, Iran, Iraq, Kuwait and the United Arab Emirates. And even with these countries, it seems, the closer you look at the detail, the less they have to offer.

Much of Saudi Arabia's reserves of oil are held in one huge field, the Ghawar. It has been pumped continually since 1948 and not surprisingly, it is showing signs of exhaustion, with its southern end now flooding with water. Saudi Arabia can keep its production roughly constant for between seven and ten years before it, too, has used up half its total oil resource and rolls over towards depletion. Then it will turn to smaller fields, producing smaller amounts, followed by poor-quality fields with real problems like Manifa. Saudi Arabia's legendary oil wealth is now coming up hard against the geology.

Reality intervenes in the case of the other Gulf states, too. Iran, which in the past was one of the young giants of the world oil business, could not now sustain a higher output for long, and there are suspicions that some of the production credited to Iran actually consists of oil piped over the border from Iraq. Kuwait and one of the Emirates, Abu Dhabi, could increase production and may well do so, but development would take several years, and their reserves are small relative to the world's demand for oil. There is, however, one country with potential for a serious increase in output, on a scale that could make a difference. The snag in this case is that the country is Iraq.

Unlike every other region with major oil potential, Iraq's oil geology is not fully explored, but there are some well-informed guesses. One estimate is that there are 110 billion barrels there, equal to more than three UK North Seas, or more than one third of the total resource once possessed by Saudi Arabia. It lies, however, in a country which is armed to the teeth, consumed by loathing of the West, and just waiting for the threat of armed intervention from America to make its day. Iraq was prevented from selling off its oil during the 1990s, when prices were lower than they will ever be again; it will soon be well placed to apply its own sanctions to the rest of the world by fine-tuning its oil production and naming its price.

The most shocking quality of this story is that it is not new. The essential problem has been known for a very long time. It is a well established fact, written up exhaustively in the literature, that the period around the turn of the millennium would mark the end of growth in the world production of oil, and the start of its long decline towards depletion. Consistent forecasts of the 'peak' - the moment when oil production turns down - have been routine for half a century [5]. In 1956 the geologist King Hubbert correctly forecast that America's oil production would peak around 1970 [6]. In 1970, Esso forecast that total world petroleum deposits would turn out to be about 2,100 billion barrels, very close to Colin Campbell's current estimate [7]. In 1976, the UK's Department of Energy published its paper Energy Research and Development in the United Kingdom: A Discussion Document; it pointed out that the UK's North Sea production would peak around the end of the century - the same time as the peak in world oil production; it would therefore be a good idea, its report concluded, to be ready with alternative supplies of energy [8]. The Global Report to the President, commissioned by Jimmy Carter and published in 1982, noted that if there were no contraint in demand, the peak would occur in the 1990s, but this would be slightly postponed if (as happened) there were to be any attempt to enforce higher prices: 'Conveninet, easily transported, relatively clean-buring petroleum and natural gas resources are being depleted'. Its recommended action: 'As these resources become increasingly scarce, a transition to other forms of energy must be made' [9].

The procession of unheeded warnings has continued. Individual energy analysts, notably Colin Campbell, Buzz Lvanhoe, Jean La heherrère and, more recently, Roger Bentley, have produced a series of detailed empirical studies showing that the turning point for oil would occur around the turn of the century [10]. In November 1998, the International Energy Agency (IEA) showed that growth in world oil output could not be expected to continue beyond about 2001 [11]. And, in mid 2000, a member of the conservative United States Geological Survey (USGS), published on the Internet his master-class on 'the Big Rollover - when the demand for oil outstrips the capacity to produce it'. It concludes, 'Hang on tight. If we don't recognise the problem soon and deal with it, it's going to be quite a ride! [12]

An oil-price shock is likely in the opening years of the twenty-first century.

The reputable forecasts, then, have consistently indicated that an oil-price shock is likely in the near future, and that its impact will get worse as time goes by. Why, then, have they been ognored? If the problem were really serious, surely - in this

society rich with economists and experts - we would have been told? Not necessarily. The principles of economic thought which are so successfully used as an aid to understanding how the market economy works break down when they are applied to natural resources such as oil.

There are four ways in which the unquestioned principles of conventional conventional market economics do not apply in this case. The first arises from the fact that the price of oil today has virtually no influence on the rate at which it is discovered. In conventional conventional market economics, the rules of supply and demand hold good: if the price of something goes up, then this gives a signal to someone to produce more of it; new producers will pile into the market until the price settles down again. In the oil market, price does not have this effect. In the early days, the best and biggest fields were quick to be found, and very cheap to pump. In fact, a new well did not have to be pumped at all; it just gushed. This cheap-to-produce and very useful fuel was immensely profitable, so the world's resources were prospected urgently and rapidly and, with the help of digital seismic technology, the discovery of oil grew to a peak in the mid 1960s. Since 1965, however, the discovery of oil has declined by approximatey 70% [13].

This means that we are using oil now which was discovered over forty years ago, in the period when oil was being found in huge quantities. That period of discovery is over. There is no conceivable increase in prices, nor any prospective technological advance [14], which will bring it back. As we use up more and more of the oil fields which were discovered in the past, it is becoming harder and harder to sustain the growth of production. Soon production will decline. The famous 'price signal' which is supposd to kick in at that point will have absolutelu no effect. It is an impasse to which the well-behaved theories of prices, supply and demand are irrelevant.

The second breakdown in the well-behaved thinking of conventional conventional market economics occurs with a failure to grasp the significance of the 'peak' in the supply of oil. There is still a large quantity of oil in the ground; we are probably not yet even half way through the total quantity of recoverable conventional oil; we shall never run out of oil, because there will always be some left to pump, and as evidence for this there are the oil wells in Pennsylvania which are still nodding away after more than a hundred years. What matters is not the quantity of oil that remains, but the turning point at which the flow of oil hits its peak - when producers are forced to turn to the smaller wells from which it is impossible to sustain the massive flows of earlier years. It is here that we come to the parting of the ways between what the market needs and what the industry can produce.

The third way in which oil insults the received rules of economics is that it cannot usefully be discussed in abstract terms such as 'reduced dependency' and 'falling percentages.' The British press and government have persistently argued that the world's dependency on oil has declined during the last three decades, and this, it is claimed, means that the market is much less vulnerable to prices and disruptions affecting oil than it was in, say, 1973. Certainly, this is the UK government's position: 'In effect, people have substituted away from oil and oil product consumption', wrote John Battle, the then Energy Minister, in 1999 (again in reply to a letter from Tim Yeo), and this theme was taken up by Helen Liddell for whom 'the declining reliance of the world economy on oil' is another of the factors which 'counterbalance fears regarding the peak in oil production' [15]. The Financial Times admiringly quotes calculations of the effect of high oil prices on corporate profits: $40 a barrel? That would merely reduce corporate profit growth from 13% to 12%. No problem. It summarised:

'These projections reflect the fact that the corporate sector - and western economies as a whole - have become far less dependent on oil. As a proportion of output, OECD oil and gas imports were three and a half times higher in 1978 than they are now.' [16]

Less dependent? Even if oil accounted for no more than one percent of the total quantity of energy used, and that one percent provided the fuel for transport, then disruptions to the supply of oil can close an economy down within days. Arcane calculations about the impact of oil prices on growth rates have nothing to do with it. While it is true that oil has declined from 45 percent to 33 percent of all energy used in the UK since 1973, the volume of transport, which depends entirely on oil, has doubled. We are twice as dependent on transport as we were in 1973. The economists' arguments about 'reduced dependency' would be entirely correct were it not for one little snag: we do not fill up our cars with percentages.

Our reliance on a secure flow of oil to underpin our economic and social order is total.

The 'reduced dependency' argument, then, is absurd. The world uses 30% more oil now than it did in 1970, and the fact that its consumption of gas has doubled does not mean that it is less dependent on oil; it simply means that it has become more dependent on gas, too. In the case of the UK, the consumption of gas and oil combined has grown from 50% to 70% of energy consumption. Secure supplies of gas itself cannot be expected to last

significantly beyond 2020 [17]; this date would be brought forward substantially if there were any large-scale switch from oil to gas for transport, and the switch itself woud require a transition period of 5-10 years in order to become a serious solution. There is therefore not a shred of justification for arguing that we are less dependent on oil. Our reliance on a secure flow of oil to underpin our economic and social order is, at present, total.

Expertise, it seems, wipes the mind clean of common sense.

The fourth way in which well-behaved economic analysis throws us off the scent of the oil shock is that it prefers to ignore time-lags. Specifically, it makes simple assumptions that other sources of energy, from renewable sources - such as solar and wind power - will come on stream as soon as the 'price signal' of high oil prices kicks in,;when it does so, renewables will flood into our homes and cars and solve our problems. The belief is persistent that ingenuity will come to the rescue - to take the case of transport alone - with shared, gas-powered and much smaller cars (goods vehicles too, maybe), opening up a smooth and speedy path to a post-oil economy. What is really worrying the Opec countries, argues Anatole Kaletsky in The Times, is the danger of alternative energy sources bringing the demand for oil to a premature end: 'The Saudis, in particular, realise that oil demand could collapse well before their kingdom has the chance to sell off its oil reserves.' [18]

The problem is, however, that the development of those alternative energy sources will take a long time. Look at the scale of the task, to take just the transport case again: build solar / wind / biomass facilities to generate electricity; use the electricity to produce hydrogen; distribute this hydrogen at an ultra-low temperature (-150ºC) to 'petrol-stations' fitted with the robots needed to deliver it into cars and trucks fitted with fuel-cells, cut dependency on road transport by some 75%...Natural gas clearly has a useful contribution to make here but, given the time it would take to switch to natural gas and the coming peak in the flow of gas itself, this contribution will be quite limited. For energy as a whole, the UK government's own target in 2000 was that renewable sources should, by 2010, account for just 2% of current final demand. A detailed study, published by the LTI-Research Group in Mannheim in 1998, found that, if the development of renewable energy systems were supported by decisive, well-coordinated action by governments, in a sustained programme lasting for fifty years, then it would be possible to provide energy from them equal to 35% of the energy used at present - but it would take fifty years to do so.[19]

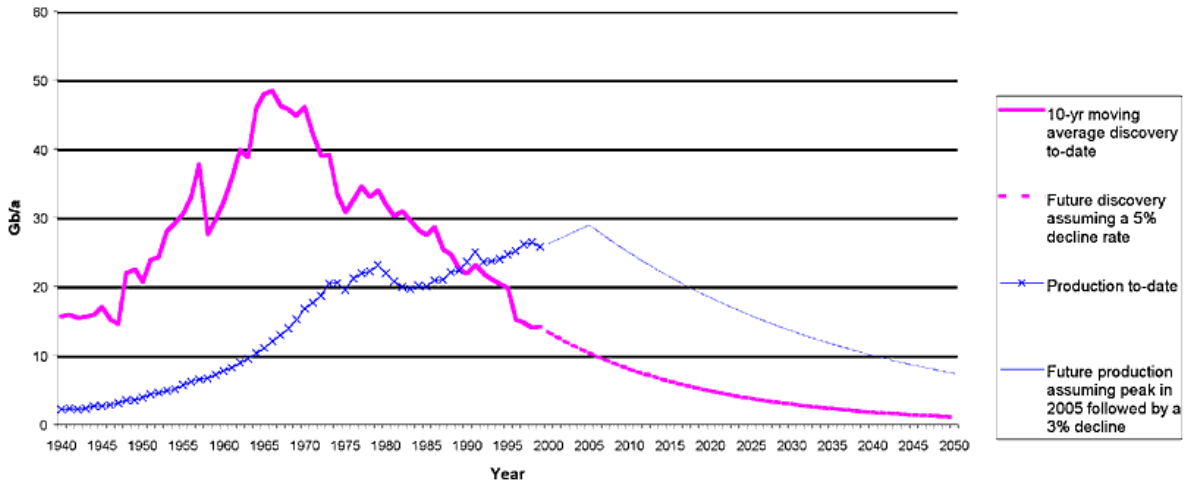
If more efficient ways of using energy (e.g. conservation methods and super-efficient technologies) were both developed at the same time as a reduction in the need for energy servcices (e.g. more compact ways of using land), this 35% might conceivably give us all the energy we needed in fifty years, and if it were given the highest possible urgency, then, perhaps, it could be done in twenty-five years. It follows that, if we wait in the approved economic manner for the market to give the 'price signal' that renewable forms of energy should now be developed, we shall ensure that the job starts twenty five years too late. It also follows that, even if the shock were not imminent after all and, instead, were postponed for ten years, while an intensive programme to develop renewables started straight away, it would still have started fifteen years too late to avoid a destabilising 'energy gap' before the alternatives are functioning properly.

In fact, our twenty-five year estimate of the time needed ofr a shift from dependency on oil is doubly optimistic, because the LTI-research group's own estimate of fifty years is based on the assumption of the comfortable background of a fully functioning economy with no disruptions to transport or industry or to any of the other conditions of normality. In reality, the switch into renewables will have to take place against a background of the oil shock, with all its consequences, which will make it more difficult to put into effect a decisive coordinated programme on anything at all.

It is evident, therefore, that one of the reasons why we find ourselves in this surreal situation, with imminent and devastating change unrecognised by the experts and discounted by government, is that the problem falls outside the mind-set of conventional market economics. Expertise, it seems, wipes the mind clean of commonsense. Maybe, for a moment, we should stop thinking, and just feel the reality of energy famine. In the poorer countries there are already people who, in the last few months, have found that the cost of paraffin which they use for cooking places it beyond their reach. After the peak, consumers all over the world will be in trouble, not because oil is expensive, but because it is not there.

The economics of oil is now dominated by its close proximity to the peak, and the graph below shows the peak that could be expected in 2005. In fact, the global peak will not take the usual form of a simple turning-point; instead, as the rate of increase in production begins to slow down, price increases will begin to speed up, suppressing demand and slowing the rate of growth in production even more. The markets will go into 'contango'. Buyers will want to buy more oil today - ie for delivery straight away, since it will be cheaper than oil in the future, while sellers will have an incentive to hold back the supply of oil today, since the oil that is still

in the ground is appreciating in value. Eventually, the price of today's oil will catch up with that of future oil, returning the market to order and equilibrium, but at a much higher price. Oil production will tend to flatten off towards a plateau for a few years, followed by a relatively abrupt downturn onto the path towards exhaustion.



The steep decline in the discovery of oil since 1965 means that, at some point, production must begin to decline itself. This is expected to happen around 2005.

The three main purposes for which oil is used worldwide are food, transport and heating. Agriculture is almost entirely dependent on reliable supplies of oil for cultivation and for pumping water, and on gas for its fertilisers; in addition, for every calorie of energy used by agriculture itself, five more are used for processing, storage, and distribution [20]. Since farming and the food industry are not famous for spending money unnecessarily, there must be a presumption that there is very little short-term 'slack' which would allow its demand for energy to be reduced at shor notice without disruptions in food prices. In the case of transport and heating fuel, there is more scope for saving energy at short notice; cutting leisure journeys, for instance, wearing extra pullovers and, in the slightly longer term, driving smaller cars have a role to play while, in the longer term, there is a totally different low-energy paradigm wating to be developed. But it is the short term that has to be survived first, and in that short term, the competition for oil for food, transport and heating will be real and raw.

One hitherto cuddly competitor which will abruptly reveal another side to its character will be the United states. America will fight hard and dirty, for three reasons. Its economy is organised irrevocably around the assumption of cheap transport, and any failure to keep its automobile economy going would be even

more damaging there than it would in other developed economies. It has, at the moment, a lot of money, and it can afford to bid high. And, America has the additional problem that it is facing not just a shortfall in the supply of oil but, at the same time, a progressive reduction in the supply of gas; it already relies on gas imports from Canada, whose own reserves are now depleting rapidly [21]. The timing is vicious: just at the moment when the world's supply of oil starts to decline, the United States will have a new and pressing incentive to increase its consumption of oil. American households will have the choice of freezing to death in unheated homes or - for only as long as the purchasing power of the dollars lasts - paying very high prices for oil.

The world market as a whole will strain to cope with the prices, but the scarcities themselves will intensify. There will be serious economic contraction and destabilisation. Unless the installation of alternatives to replace both oil and gas moves ahead at an extraordinary speed, the deconstruction will get rapidly worse as the supplies of oil, and then gas, go into decline. The market economy in its present form will not survive this sudden loss of cheap and abundant energy.

REFERENCES

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2 Donella Meadows, Dennis Meadows, Jørgen Randers and Willian Behrens (1972*), The Limits to Growth*, London: Earth Island. It was criticised in (for instance) H.S.D Cole, Christopher Freeman, Marie Jahoda and K.L.R.Pavitt (1973*), Thinking about the Future: A Critique of The Limits to Growth'*, London: Chatto and Windus for Sussex University Press; William D. Nordhaus (1973), 'World Dynamics: Measurement without Data', *Economic Journal* December; Wilfred Beckerman (1990), *An Introduction to National Income Analysis*, London: Weidenfeld and Nicholson, (third edition; first published 1968); Robert M. Solow (1974), 'The Economics of Resources or the Resources of Economics', *American Economic Review*, Papers and Proceedings (May); Mancur Olson and Hans H. Landsberg, eds. (1975), *The No-Growth Society*, London: Woburn Press.

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5 The decisive paper on this was by M. King Hubbert (1949), 'Energy from Fossil Fuels', *Science*, 109, pp.103-9. See Hardin, Garrett (1993*), Living Within Limits: Ecology, Economics and Population Taboos*. London: Oxford University Press, p.138.

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8 UK Department of Energy (1976*), Energy Research and Development in the United Kingdom*, Energy Paper Number 11, Her Majesty's Stationery Office.

9 Gerald 0. Barney (1982*), The Global 2000 Report to the President: Entering the Twenty-First Century*, Penguin, p.351. The report showed that, if demand were held constant at the level it reached in 1975, the turning point to a precipitous decline into depletion could be postponed until about 2025 while, in the absence of any attempt to control prices (by, for instance, the OPEC cartel), the peak would occur at the start of the 1990s. On this basis, the slight constraint that has actually occurred in demand, due to relatively high prices over much of the period 1975-2000, would have been expected to lead to a peak in the period of 2000-05.

10 Colin Campbell (1997), *The Coming Oil Crisis*, Brentwood, UK: Multi Science. L.F. Ivanhoe (1996), 'Updated Hubbert Curves Analyse World Oil Supply', *World Oil*, November pp.91-4. Jean Laherrère discovered the 'parabolic fractal', (as explained by Campbell (1997), p.176), 'the law of distribution stating that objects in a natural domain plot as a parabola when their size is compared with their rank on a log-log format. For example, the populations of the larger towns can be plotted to yield the population of a country down to the smallest settlement. It means that when the larger oilfields have been found, their size distribution can be used to predict what the i recovery will be.' Jean Laherrère (1996), 'Distributions de type <fractal parabolique> dans la nature', C.R. Acad. Sci., Paris 322 Iia 535-41; cited in Campbell (1997)). Roger Bentley's (1998 and later revisions), UK Energy: The Next 5-10 Years, a report submitted without effect to the Department of Trade & Industry, UK, by the Department of Cybernetics, University of Reading, is a summary-synthesis of all the main relevant data on oil discoveries, reserves and future supplies. See also: Hooshang Amirahmadi (1996), 'Oil at the Turn of the Twenty First Century', *Futures*, 28,5, pp.433-52.

11 lEA (International Energy Agency) (1998), World Energy Outlook, Paris: OECD. This is analysed in David Fleming (1999), 'The Next Oil Shock?' *Prospect*, April, pp.12-13; and in David Fleming (1999b), 'Decoding a Message about the Market for Oil', *European Environment*, 9, 4, July-August, pp.124-34. The lEA's forecast took the form of an analysis of showing what would have to happen in order to achieve a sustained production growth of 1.8% a year, allowing the reader to decide for himself whether that scenario was plausible or not. The Agency later confirmed, as concluded in the above papers, that this was in effect issued a coded warning of a turning point in oil supplies around 2000.

12 www.oilcrisis.com/magoon/ (2000).

13 This analysis is set out in various forms in the references cited above, but see also Matthew Simmons (2000), *An Energy White Paper*, http://www.simmonsco-intl.com/research/: 'The reality of the world's oil production base as we begin the twenty-first century is that all the super giant fields are now very old with high water cuts and steep decline curves. Most of these giant fields are now mere pygmies through rising decline rates'.

14 Confidence in 'technological improvements relating to discovery and recovery rates' was expressed by, for instance, by Helen Liddell, the UK's Energy Minister at the time, in her reply to a letter from Tim Yeo, Shadow Agriculture Minister, 10 May 2000.

15 Letters to Tim Yeo, MP, 8 April, 1999 and 10 May 2000.

16 'Pouring Oil on Troubled Markets', Leading article, *Financial Times*, 30 September, 2000.

17 The International Energy Agency's projections of gas supplies on the basis of business as usual (BAU) suggest that gas production from all OECD sources will peak in 2015, and that the OECD's share of the market will fall from around 45% at present to 30% and falling in 2020. The major sources of supply will be the Transition Economies (the former Soviet Union), the Middle East and South & East Asia, which will, collectively, have a 55% share of the market, while China, significantly, will have only a 2% share. This concentration of supply, the declining production from the OECD and the political tensions arising from gas-rich economies bordering on a gas-poor China suggest the probability of both price- and geopolitical-instability in the gas market. Moreover, the rise in oil pries means that there will be both a higher demand and higher prices for gas than the BAU projections indicate. This suggests that the estimated peak in OECD gas output should be brought forward to around 2010. After that, gas prices will be much higher, and a global peak in production, with severe price volatilities, can be expected to develop during the second decade of the century. See also J.H. Laherrère, A. Perrodon and CJ. Campbell (1966), *The World's Gas Potential*, Geneva: Petroconsultants S.A., and lEA (1998); USGS (1) and (2) CHECK

18 Anatole Kaletsky (2000), 'This Oil Shock Will Not Put the Skids under Growth', *The Times*, 3 October, p.27.

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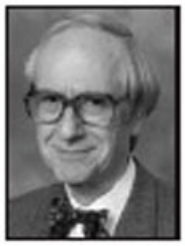
Conference, *What Energy Options for Europe in 2020?*, 4-5 December, Brussels. Bentley writes, 'Going by the North American experience (which is more-or-less at peak on gas), [the] proportion for the gas peak is around three-quarters. How-ever, unlike oil which declines gently when the peak is reached, gas production past peak falls off a cliff.' (p.3)

WEBSITE CONNECTIONS

The oil peak: www.hubbertpeak.com and www.oilcrisis.com/magoon/

Fuel rationing: www.dtqs.org



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David Fleming is an independent policy analyst specialising on the impact that environmental change will have on the global market economy in the early decades of the 21st century. His book *The Lean Economy* describes the consequences of the coming oil price shock and climate change. It discusses four types of solution: lean production, lean distribution, lean design and lean culture. He holds an MBA and has worked in the textile, detergent, advertising and financial services industries. He was economics spokesman of the English Green Party between 1977 and 1980 and chairman of the Soil Association between 1988 and 1991. In 1979 he began studies in economics at Birkbeck College, University of London, completing an MSc in 1982 and a PhD on the economics of the market for positional goods in 1988. He lives in London.

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