Background paper 2

Sustainable Development, Climate Change and Energy Use

A. Models of Sustainable Development

Sustainable development, as a global agenda, concerns itself essentially with conservation of the natural resources and environment upon which all human economic and social development ultimately depends. A growth-based global economy, relying on continuous growth in the consumption of natural resources (through an increasing population and increasing standards of living) has ultimate limits, as brought to public attention in the famous 1972 publication, Limits to Growth.[1]

The human economy interacts with the physical environment through inputs of raw material (from sources) and outputs of waste (to sinks). The authors of the *Limits to Growth* argued that there were a number of inter-related areas where the natural environment is treated as a source or as sink (in some cases both) which could become critical in limiting growth in the future depending on the scenario.

The emphasis in *Limits to Growth* was on resource constraints as the impacts of pollution, such as greenhouse gas emissions, were more difficult to trace than they are today. However, while the international community, following the Brundtland Report in 1987 and the 1992 Earth Summit, has begun to address a range of sustainable development issues, it has been global warming that has increasingly been the focus.

The report to the World Commission on Environment and Development (the Brundtland Report of 1987) included various explanations of the meaning of sustainable development including one widely referred to:

'Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'[2]

This simplified definition tends to raise more questions than it answers (What and whose needs? Which future generations and what will their needs be?) However, it focuses attention on human needs as against wants and managing resources in the present within a long-term time frame, in line with the argument of Limits to Growth.

The 'Declaration of Rio on Environment and Development', 1992, presented the inter-governmental agreement on a concept of sustainable development as a balance of the three dimensions (or 'poles') of Environmental Protection, Economic Growth and Social Development.[3] (This is often represented in a 'Venn' diagram of three overlapping circles, with sustainable development falling in the central area of overlap between the three dimensions of different interests, or as a 'Russian doll'

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[1] Meadows, D. H, Meadows, D L, Randers, R and Behrens, W W. 1972. *Limits to Growth.* Universe Books. See also: Meadows, D L, Randers, R and Meadows D. H. 2004. *Limits to Growth: The 30-Year Update.* Chelsea Green Publishing Company.

[2] Brundtland G. (ed.) 1987. *Our Common Future: The World Commission on Environment and Development,* Oxford: Oxford University Press.

[3] United Nations NGO Committee on Sustainable Development. <www.unngocsd.org/CSD_Definitions%20SD.htm>.

model, which embeds human society and economy within a larger context of the global environment (Figure BP 2.1).[4]

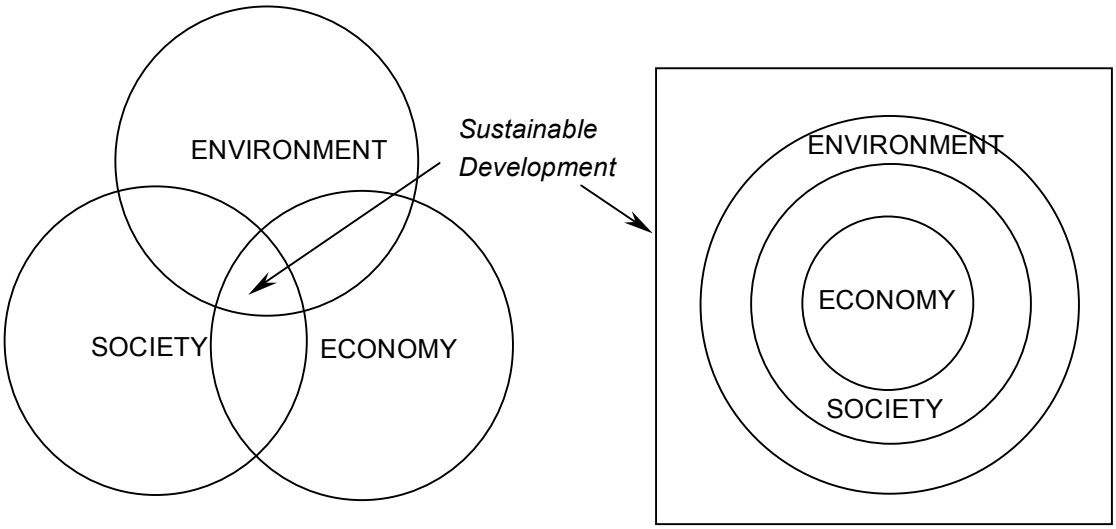

Figure BP 2.1 Models of Sustainable Development

B. Worldwide factors of pollution, climate change and carbon reductions

While all longer term projections of future resource and environmental constraints on growth are based on a high degree of uncertainty, the more this is so where, in the case of climate change, we are talking about not a dwindling resource but a sensitive and complex balance of system factors, each of which carried its own high level of uncertainty and degree of unknown.[5] The damage to these systems by the human processing of finite resources is already taking place well before the exhaustion of those resources.

The most informed scientific view we have now, and the one accepted by all governments in the UN, is that human activity is causing a warming of the earth through the impact of the greenhouse gases we produce. The most important of these is carbon dioxide from the burning of fossil fuels and, to a lesser degree from deforestation (both from burning and the loss of vegetation as a major carbon sink). Much of the release of CO_2 is related to activities in and around urban areas (See Section D). Deforestation is related to the growth of agriculture, which is also a major source of methane, the second most important greenhouse gas in terms of climate change impacts. Other greenhouse gases (GHGs) are far more powerful in their

[4] O'Riordan, T and Voisey, H (eds). 1998 *Transition to Sustainability*. London. Earthscan.

[5] Current understanding of these issues is being further through the development of the Earth Systems approach and the use of sophisticated computer models, both pre-figured In *Limits to Growth*.

impacts than CO_2 but (apart from methane) the impact of emissions is small and they are easier to reduce.

However, we have only a 'best guess' of what the climate change impacts due to greenhouse gas emissions will be. The best estimate of the Intergovernmental Panel on Climate Change (IPPC) for the temperature rise for the decade leading up to 2100 is 1.8 to 4°C relative to the period 1980-1999 (with a likely range of 1.1 to 6.4°C) and an anticipated sea level rise of 28 to 43cm.[6] A number of observers are suggesting that little can be done to avoid a worst case scenario of more than 5°C.

It is recognised by scientists that temperature rise is unlikely to be a steady process and there have been short periods of cooling last a decade or two against a longer term trend of steady temperature increases over two centuries. A cooler period after the Second World War has been attributed to the effect of aerosols, particulate pollutants from heavy industrial development in Europe since cleaned up.[7] More recently, scientists predict that the long-term temperature changes associated with oceanic currents lasting up to 2020 will induce a relatively cool spell that may counter global warming.[8] This implies that projecting forward current climatic conditions may be the safest basis on which to design retrofitting measures for the short to medium term.

According to a report by the Global Carbon Project, data on carbon dioxide emissions shows that, despite the Kyoto agreement, the growth rate was 3.2 per cent in the five years to 2005 compared with 0.8 per cent from 1990 to 1999.[9] Two thirds of this increase is due to faster economic growth including the expanding Chinese economy with its heavy fossil fuel use. The remaining third is due to a halt in carbon intensity reduction that had marked earlier years, and a reduction in the capacity of natural sinks which have been declining for 50 years, to remove emissions from the air.[10]

The rate and pace of change is uncertain as many factors which could accelerate the process, or which may slow it down in the short term (or even long term) come into play. Sceptics claim that, given the degree of uncertainty, the whole argument for human-induced climate change is flawed, politically-motivated and should be abandoned.

However, there is little scientifically accepted evidence for alternative explanations of climate change offered by the sceptics. A wider body of opinion accepts the arguments for climate change but, again because of the uncertainties or perhaps because of the climate changes that are now unavoidable, suggests we would be better putting resources into adaptation rather than mitigation. The mainstream view,

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[6] Intergovernmental Panel on Climate Change. 2007. *Climate Change 2007: Synthesis Report, Summary for Policymakers.* November.
[7] Black, R. 2008. 'Next decade 'may see no warming'', BBC News. 1 May. <http://news.bbc.co.uk/1/hi/sci/tech/7376301.stm>.
[8] Greater London Authority. 2006. *London's Urban Heat Island: A Summary for Decision Makers*, London: Greater London Authority. Available from: <www.london.gov.uk/mayor/environment/climate–change/docs/UHI_summary_report.pdf>.
[9] Global Carbon Project. *Press Information.* <www.globalcarbonproject.org/activities/AcceleratingAtmosphericCO2.htm>
[10] Ibid.

although by no means universally accepted, is that of the Stern Report, which suggests that short term investment in mitigation will be far more cost effective than simply adapting to changes as they happen.

The view of this study is that mitigation and adaptation should be seen as two sides of the coin. Whatever risks and uncertainties remain, the *precautionary* principle[11] as argued below, suggests we should give immediate and urgent concern to mitigation measures. In considering mitigation, however, we should recognise that there will be global warming and that longer-term measures have to be planned to take account of conditions as they are likely to be, in some decades hence.

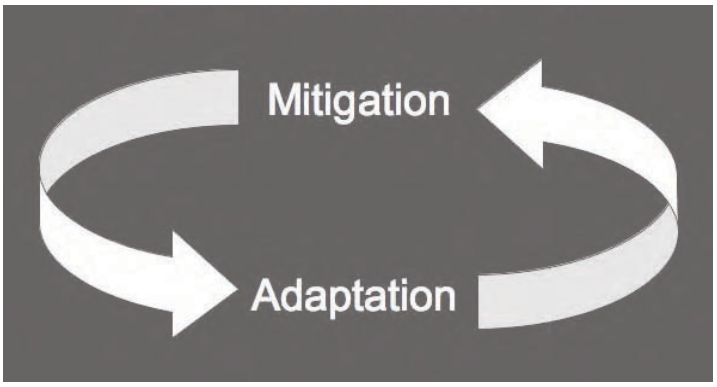

Figure BP 2.2: Mitigation of and adaptation to climate change are inter-related

C. Climate Change and Energy

The sting in the tail of the climate change argument is that a combination of factors, and positive feedback that accelerates the pace of change, could lead to a destabilisation of the relatively recent 'equilibrium' of the earth's climate and to 'runaway' climate change. We then move into the arena of catastrophic change, where the normal economic rules cease to apply.

Whether the 'tipping point' argument is accepted or not, the precautionary principle suggests that, on behalf of the future generations, we should not take the risk. Moreover, in the larger concept of sustainable development, whatever the unknowns, polluting activities invariably carry costs that become unsustainable in a regime of indefinite increasing population and economic growth. At some point in the future, governments might come to agree the appropriate use of 'sustainable sinks' but that would require a stabilised global population and wholly different order of management of the global economy to the one we have now and proportionately greater understanding of how the natural environment works.

[11] According to the European Commission Communication of 2 February 2000: 'The precautionary principle applies where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen by the EU' <http://ec.europa.eu/dgs/health_consumer/library/pub/pub07_en.pdf>.

The climate change agenda took a leading position on the international agenda after the Earth Summit of 1992. This resulted in the Kyoto Agreement of 1996, which set binding targets for carbon emissions for 2012 for all the governments that signed up to it. Some key nations, particularly the United States, by far the biggest carbon emitter at the time, refused to sign up. Developing nations, including China and India who are now among the highest carbon emitters as nations (if still low in per capita terms), stayed out of the agreement.

With the publication of the recent IPCC report, the climate change agenda has taken on a greater urgency and there is broad international agreement that a post-Kyoto treaty will have to involve all the key players and a huge mobilisation of political will. The US, for example, which was due to achieve a reduction under the Kyoto Protocol, has increased its emissions by 16.3% in the meantime.

Although many measures have been introduced in Europe, which has led the way in policies for mitigation, the EU is currently below the trajectory needed to meet its GHG emission target of 8% reduction by 2012 (it had achieved a 2% reduction by 2006), although it is argued new measures put in place in 2008 will put it back on track. An extension of this target to 20% by 2020 has been agreed by the EU.

Clearly, measures to mitigate the impact of carbon emissions need to take effect as soon as possible. Current UK government policy objectives require us to reduce our GHG emissions by 60% between 2000 and 2050 with the Prime Minister recently committing to an 80% reduction. The immediate targets are those of the Kyoto Agreement – 12.5% reduction in 2012 on 1990, a figure that had been exceeded by 2006 with a reduction of 15.7% (although the extended national target for 2012 of 20% may not be achieved).

Within the EU, however, while some countries are ahead of their targets, others, notably Spain and Italy, are far behind and the challenges of meeting the collective target remain. International aviation and navigation – are not covered by the Kyoto Protocol or EU policies and measures. These currently represent 6% of emissions in the EU but have grown 44% across the EU between 1990 and 2002 and clearly present major challenges to meeting future targets.[12]

Moreover, the UK achievements should be seen in context. The five non-CO_2 gases in the Kyoto agreement account for about 15% of GHG emissions in the UK, but half the emissions reduction to date.[13] (Across the EU they account for the whole reduction, and CO_2 emissions in the EU 15 pre-enlargement members have actually increased since 1990). Much of this reduction comes from one-off changes in industrial processes and cannot be expected to contribute as much in the future as in the past.

Oxford Energy Study Institute sets out the challenges of reducing CO_2 in the UK and EU.[14] Significant reductions in CO_2 took place between 1970 and 1995, with emissions falling by 20% or more in the UK, France and Germany and lesser rates of reduced emissions in other EU countries. This predated Kyoto and reflected

[12] Oxford Institute for Energy Studies. 2005. Oxford Energy Comment, February. <www.oxfordenergy.org/comment.php?0502>.
[13] Ibid.

industrial restructuring, the growth of nuclear power (particularly in France) and the replacement of coal by gas, especially in the British domestic and power generation sectors.

Certainly these factors, including the move from coal to natural gas with the arrival of North Sea gas, are largely responsible for the UK keeping well within its targets. However, these are one-off changes and actually bringing about CO_2 reductions as a result of policy has hardly got off the ground. To meet its 2030 target, the UK needs to be looking at all its options, including the more challenging ones of phasing in new sources of clean energy production, discussed below, but particularly at reducing energy consumption. Buildings are the biggest and, in theory, easiest target in this respect, as new buildings and services can be built to higher performance standards but there are huge opportunities for sustainable renovation.

Energy supply options

Most of the natural resources we use are land (or near land) based and in terms of political economy, 'territorialised'. That means issues of security of supply, national interest and potential trans-national conflict are never far away when governments are dealing with strategic resources like food production and energy supply, whatever their ostensible commitment to global free trade. This is an important factor in considering the future price of fuels since a crisis in supply means that the main producers always look to securing their own national supplies as a priority.

Theoretical limits to the supply of resources vary between those that are difficult or impossible to substitute for (water, air) and those that are more or less costly to substitute for. Energy has a pivotal role, in that we have used increasing amounts of it to access and make more intense use of other natural resources such as land and minerals, and to overcome the costs of substituting one natural resource for another. The industrialisation of the world that has bought a vast increase in disposal income and consumption to ever increasing numbers is totally dependent on the supply of cheap energy, in the main from fossil fuels.

The pool of fossil fuels which, as far as electricity generation is concerned, can be substituted for one another, is large but not infinite. The timescale for depletion is measured at current increasing rates of consumption in decades rather than hundreds of years.[15] Alternative energy sources, as in the case of nuclear, may be very costly requiring large capital outlays, long periods to come on line and extended or uncertain payback periods and safe waste disposal costs.

Renewables can go some way to filling the gap as far as electricity production is concerned although, with the exception of tidal power generation and some deep reservoir-backed hydro electricity schemes, their output varies with weather conditions and back up from fossil fuel or nuclear plants will continue to be needed. Additionally, the UK has a lot of ground to make up with renewables currently making up about 5.5% of energy supply.[16] Many wind farm schemes remain bogged down

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[14] Ibid.

[15] Energy Information Administration. 2008. *World Consumption of Primary Energy by Energy Type and Selected Country Groups (U.S. Physical Units)*, 1980-2005. <www.eia.doe.gov/iea/wec.html>.

[16] Ofgem. Renewables Obligation - What is the Renewables Obligation (RO)? <www.carbontrust.co.uk/climatechange/policy/renewables_obligation.htm>.

with planning issues.[17] So far, Government has refused to countenance the kind of subsidised feed-in tariff scheme that has kick-started micro-generation from wind power or photovoltaics in Germany and other EU countries.

One of the best current options would appear to be greater use of combined heat and power (CHP or 'co-generation') or combined cooling, heat and power (CCHP or 'tri-generation') schemes. These are commonly gas-fuelled, though there are opportunities for greater use of biomass fuels in the future. Even where the fuel is gas, however, the far greater efficiencies in the use of fuel can have a major impact of our consumption and the simple replacement of aging gas boilers with new, more energy efficiency models could therefore also have a major impact.

Uncertainty in supply, substitution technologies and price fluctuation

In the current global economic context, energy prices are likely to remain volatile, with the recent spike in the price of oil to $140/barrel, largely driven by financial speculation, being followed by a collapse to below $50/ barrel as the Western World would moves into recession.

There is no consensus about how much of the oil that ultimately lies in the ground can be recovered economically. What is economical to recover depends on oil prices. Estimates of recoverable oil are unreliable (often over-estimated for political reasons) while new fields are being discovered, as recently the deep sea fields off the Brazilian coast and new North Sea reserves. However, as the most accessible oil is already being tapped, and new fields are more inaccessible and costly to tap, the underlying cost of oil is likely to remain high and almost certain to increase in the long term.[18]

Some commentators argue that 'peak oil' – the point of maximum production after which levels begin to decline – has already been reached. Once increasing supply starts to eat into a reduced supply, then reserves disappear rapidly and the perception of limited supplies and producer governments' inclination to ration production to meet domestic energy security needs, or as a negotiating measure, will force up prices on a permanent basis.

Against this background of volatile but generally upward price pressures on oil, there will also be increasing demands for oil substitutes, notably gas and coal in electricity production and biofuels for transportation. Global prices for gas and coal have risen or fallen in line with the oil price in recent years.

According to one report late last year, by the German-based Energy Watch Group (EWG), world oil production peaked in 2006 and will fall by half as soon as 2030.[19] According to EWG's founder Hans-Josef Fell, the MP behind Germany's support

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[17] References to Lewis Wind Power scheme, Planning 2 May 2008; Shell pulling out of large Kent offshore scheme.

[18] The International of Energy Agency, in its 2008 World Energy Outlook, suggests that the end of cheap oil is over, that prices could soon be back over $100 a barrel and as high as $200 by 2030. Mukherjee.S. 2008. 'Energy body warns on oil prices', *BBC News*, November. <news.bbc.co.uk/1/hi/sci/tech/7723576.stm>.

[19] Seager, A. 2007. 'Steep decline in oil production brings risk of war and unrest, says new study', Monday, 22 October, London: The Guardian.

system for renewable energy, 'the world soon will not be able to produce all the oil it needs as demand is rising while supply is falling.'

According to the International Energy Agency, global reserves of oil are about 1.255 gigabarrels - equivalent to 42 years' supply at current consumption rates. EWG estimates, based on actual oil production data are about two thirds of that. EWG predicts significant falls in gas, coal and uranium production as those energy sources are used up.[20] 42 years is only half an individual's lifespan – small indeed in planetary terms and, of course, 'current consumption rates' projected into the future do not reflect the current growth rates in consumption in emerging market economies. If the global growth of consumption for the period 1980 to 2004 is projected forward, for example, supply falls to 35 years.[21] The market and political response to such perceived supply constraints of course sets in much sooner. Indeed, a large part of the current oil price shock can be put down to such perceptions.

The International Energy Agency (IEA) is predicting a rise in global energy demand of 50-60% by 2030. As oil is getting short while coal remains cheap and plentiful, the IEA forecasts that, without a substantial increase in investment in nuclear power or effective carbon capture and storage, there will be a 50% rise in greenhouse gas emissions to meet this demand by 2030.[22]

Gas production has increased alongside and following on from increased production of oil, but natural gas fields in Siberia, Alaska and the Middle East are set to last only 20 years longer than the world's oil reserves.[23] Natural gas emits substantially less carbon than oil on an energy output basis but is still a major source of carbon emissions. It is expensive to extract and more difficult and costly to transport than oil both through pipelines and, in liquidised form, in tankers.[24]

Outlook for alternative fuels

The increased price of fossil fuels, and government subsidies, notably in the US, has made it feasible for farmers to get higher returns from growing biofuels rather than food. Sustainable production of biofuels needs a well-defined and global regulatory framework that takes into account where it is grown (it should not substitute useful food production or lead directly or indirectly to deforestation) and in terms of its relative carbon efficiency or inefficiency. While so much uncertainty remains about the sustainability of biofuel production, the pressure will remain on oil for use in vehicles.

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[20] Ibid.

[21] Energy Information Administration. 2008. World Consumption of Primary Energy by Energy Type and Selected Country Groups (U.S. Physical Units), 1980-2005. <www.eia.doe.gov/iea/wec.html>. This estimate is based on global demand increasing in the future at the same rate as it increased between 1980 and 2004. It does not take into account differential growth rates for different countries. Projected forward, China's growth in oil consumption of 6% per annum between 1980 and 2004 would mean that in 35 years it would be consuming equivalent to nearly half of the world's total consumption!

[22] Black, R. 2006. 'Energy gap: Crisis for humanity', BBC News, Thursday, 26 January. <http://news.bbc.co.uk/1/hi/sci/tech/4648710.stm>.

[23] Howden, D. 2007. 'World oil supplies are set to run out faster than expected, warn scientists', The Independent, Thursday, 14 June.

[24] Ibid.

With transport fuels, there is a different set of problems since there is currently little alternative to the use of petrol or diesel other than biofuels, where land being used for their production may compete with land being used for the production of food.

The current rapid inflation in the cost of food is the product of a complex of economic factors including the rising prosperity of emerging economies and higher consumption of meat, impacts of recent weather patterns on harvests, commodity speculation on top of supply shortages and as a hedge against a falling US dollar, and the spiralling cost of oil in response to political factors and booming world demand (including the use of oil in agricultural production). The increasing use of land to grow biofuels is a significant factor but almost certainly not the most important. However, it is one could grow rapidly in importance as production ramps up.

The increased production of biofuels is being driven, particularly in the US, by energy security at least as much as sustainability concerns. The production of corn ethanol is being subsidised by the Federal Government, competing with corn for meat producers and driving up prices. Savings on greenhouse gas emissions represent 22% over petroleum.[25] By contrast, in Brazil where alcohol has long been established as a main source of fuel, ethanol from cane represents a 55% reduction in greenhouse gas emissions.

Brazil is actively trying to sell its ethanol and ethnol producing technology abroad and there are concerns that it may have knock on effects on carbon emissions. Grazing land taken for cane production in Brazil, for example, may be driving beef producers further into the Amazon region, adding to GHG emissions through deforestation, the rate of which has risen again in recent years. Of similar concern, in this respect, is Brazil's increasing production of soyabeans, used both as an animal feed and for producing biofuel (major producer: Germany, GHG saving 68%).[26] The production of palm oil for biodiesel is causing similar concerns in Southeast Asia, leading to deforestation and the development of carbon-rich peatlands in Indonesia, where CO_2 emissions are increasing at 4% per annum.[27]

Other 'second generation' technologies that would avoid these effects are still in development. Cellulosic ethanol, which could result in up to 91% reductions in GHGs could be produced from prairie grasses, agricultural residues, and municipal and forestry wastes. Biodiesel made from algae is more promising still as it grows continuously in wastewater, or even seawater, fed by sunlight and carbon dioxide that could be 'scrubbed' from fossil fuelled power plants. [28] Theoretically, an acre of land growing algae could produce 5,000 gallons of biodiesel per year, compared with the 300 gallons of ethanol produced by an acre of corn, and 50 gallons of biodiesel produced by an acre of soyabeans.

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[25] Korne, J. 2007. 'Biofuels: Boon or Boondoggle'. *National Geographic*. October. Vol. 212 No. 4. pp38-59.
[26] Ibid.
[27] Mongabai.com. 2007. *Indonesia: No more rainforest clearing for palm oil.* June 5. <http://news.mongabay.com/2007/0605-indonesia.html>.
[28] Ibid. p57.

Of more immediate importance is that global dependence on oil combined with rapidly increasing demand and the rapid growth of middle class consumers in the emerging economies, particularly China and India, is leading to food price increases that impact disproportionately on the poor and very poor and lead to social unrest in countries across the developing world. So the political response to growing social tensions will be the immediate means by which underlying resource constraints are transmitted into action.

In the current global economic context, energy prices are likely to remain volatile. Ultimately, rising prices must result in an economic slowdown, falling demand and a price correction. The slowdown is already beginning to happen but whether this will be limited to the developed world economies, as the optimists suggest, or whether it will be global in its impact remains to be seen. In any event, the kind of rapid growth seen in China in past two decades, and in India in more recent years, is not ultimately sustainable if the world continues to be fossil fuel-dependent.

There is no consensus about how much of the oil that ultimately lies in the ground that can economically be recovered. Estimates of recoverable oil are unreliable (often over-estimated for political reasons) while new fields are being discovered, as recently the deep sea fields off the Brazilian coast. However, as the most accessible oil is already being tapped, and new fields are more inaccessible and costly to tap, the underlying cost of oil is almost certain to increase. Some commentators argue that 'peak oil' production levels have already been reached. Once increasing supply starts to eat into a reduced supply, then reserves disappear rapidly and the perception of limited supplies and producer governments own inclination to ration production will force up prices on a permanent basis.

Against this background of volatile but generally upward price pressures on oil, there will also be increasing demands for oil substitutes, notably gas and coal in electricity production and biofuels for transportation. Global prices for gas and coal have risen substantially in line with oil price hikes in recent years.

Gas production has increased alongside and following on from increased production of oil, but natural gas fields in Siberia, Alaska and the Middle East are set to last only 20 years longer than the world's oil reserves.[29] Natural gas emits substantially less carbon than oil on an energy output basis but is still a major source of carbon emissions. It is expensive to extract and more difficult and costly to transport than oil both through pipelines and in tankers.[30]

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[29] Howden, D. 2007. 'World oil supplies are set to run out faster than expected, warn scientists', The Independent, Thursday, 14 June.
[30] Ibid.

According to one report late last year, by the German-based Energy Watch Group world oil production peaked in 2006 and will fall by half as soon as 2030.[31] According to EWG's founder Hans-Josef Fell, the MP behind Germany's support system for renewable energy, 'the world soon will not be able to produce all the oil it needs as demand is rising while supply is falling.'

According to the International Energy Agency, global reserves of oil are about 1.255 gigabarrels - equivalent to 42 years' supply at current consumption rates. EWG estimates, based on actual oil production data are about two thirds of that. EWG predicts significant falls in gas, coal and uranium production as those energy sources are used up.[32] 42 years is not very long and, of course 'current consumption rates' projected into the future do not reflect the current growth rates in consumption in emerging market economies. If the global growth of consumption for the period 1980 to 2004 is projected forward, for example, supply falls to 35 years.

The International Energy Agency (IEA) is predicting a rise in global energy demand of 50-60% by 2030. As oil is getting short while coal remains cheap and plentiful, the IEA forecasts that, without a substantial increase in investment in nuclear power or effective carbon capture and storage, there will be a 50% rise in greenhouse gas to meet this demand emissions by 2030.[33]

UK energy prospects

This view of peak oil is not shared by the UK Government, which has been focusing on long-term renewed and expanded nuclear capacity and carbon capture and storage, rather than the immediate and large-scale promotion of renewables as in Germany. The Department of Business and Enterprise suggests that: 'Over the next few years, global oil production and refining capacity is expected to increase faster than demand. The world's oil resources are sufficient to sustain economic growth for the foreseeable future.'[34]

This view is supported by commercial analysts Wood Mackenzie who predict an over supply in oil processing capacity and products by 2010 as a consequence of the growth of liquid natural gas products and biofuels in the US, EU and Brazil, leading to a reduction in oil prices.[35] Goldman Sachs analysts also suggest that oil prices could fall as normal market conditions return over the next four years but fear that any major disruption to supply could lead to a 'super spike' of $200/barrel, compared with a figure, at the time of writing, of nearly $140.[36] Parliamentarians involved in the All

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[31] Seager, A. 2007. 'Steep decline in oil production brings risk of war and unrest, says new study', Monday, 22 October, London: The Guardian.
[32] Ibid.
[33] Black, R. 2006. 'Energy gap: Crisis for humanity', BBC News, Thursday, 26 January. <http://news.bbc.co.uk/1/hi/sci/tech/4648710.stm>.
[34] Ibid.
[35] Wood Mackenzie. 2007. 'Wood Mackenzie Sees Global Oil Products Oversupply by 2010 Leading to Gasoline Price Reduction'. 31st July. <www.woodmacresearch.com/cgi-bin/corp/portal/corp/corpPressDetail.jsp?oid=835168>.
[36] Gelsi, S. 2008. 'New 'super-spike' might mean $200 a barrel oil'. *Marketwatch*. 7 March. <www.marketwatch.com/news/story/goldman-sachs-raises-possibility-200/story.aspx?guid=%7B4B702F7F-41F8-45F0-A133-630F12F2C764%7D>.

Party Parliamentary Group on Peak Oil and Gas and on Climate Change are beginning to see both as issues of crisis proportions.[37]

Britain's oil production peaked in 1999 and has already dropped by half to about 1.6 million barrels a day. UK natural gas production peaked at 108 billion cubic metres (bcm) in 2000 and it is estimated that by 2010, the UK will be 50% dependent on imported supplies, rising to 80% by 2020.[38] The UK, which relies on gas to generate 38% of its electricity and 39% of its primary energy requirement (compared with 35% from oil, 15% from coal, 9% from nuclear and 2% from other sources), will be increasingly reliant on imports from Europe and elsewhere.[39]

While the 2003 Energy White Paper does not specify targets, some estimates suggest the minimum share of gas will rise to 46% or as high as 60% by 2012, in part to fill the gap from decommissioning of defunct nuclear and coal power plants.[40] Even if there is a push for nuclear, this will take some time to come on line. Although there are large reserves of gas remaining in the North Sea, which can be piped from Norway and Belgium, there will be increasing competition from across Europe, and more general reliance on outside sources like Russia. All this points to increasing energy prices and energy price volatility and diminishing energy security.

Consumer prices have been hit by price rises of up to 15% over the past year. Further increases are forecast, perhaps by as much as 40%.[41] These are massive hikes, though they may be short-term 'spikes'. If energy prices remain relatively high in the longer term, however, reflecting pending oil or gas supply constraints, this will bring greater incentives to invest in energy savings measures, including building retrofitting.

It will also encourage the development of alternative energy sources including wind farms, tidal power, biomass and solar energy, and (sustainably-produced) biofuels. It is equally likely to drive a greater push for more nuclear power and a ramping up again of coal fired electricity production (based on coal imports and revitalised UK coal production and subject, if there is any consistency in climate change policy, subject to the development of effective carbon capture and storage mechanisms).

In the longer term, coal may also be seen as potential substitute for oil in fuelling vehicles. At present, the production of coal-to-liquid (CTL) fuels emit nearly double the carbon dioxide to that of the equivalent amount of petrol production, but there is strong interest in developing the technology to clean up its production, particularly in the USA which has by far the world's largest coal reserves.[42]

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[37] All Party Parliamentary Group on Peak Oil and Gas. Peak Oil & Climate Change - Twin Crises? <www.appgopo.org.uk/index.php?option=com_content&task=view&id=18>.
[38] Parliamentary Office of Science and Technology, 2004. *The Future of UK Gas Supplies, Postnote No 230*, October.
[39] Ibid.
[40] Ibid.
[41] Seager, A. 2008. 'Domestic energy bills expected to soar as cost of oil keeps increasing'. *The Guardian,* 9 June.
[42] Clayton, M. 2007. 'Coal in cars: great fuel or climate foe?', *The Christian Science Monitor*. 2 March. <www.csmonitor.com/2007/0302/p02s01-ussc.html>.

It is worth noting, however, that in the final four decades of the last century energy had been steadily getting cheaper. This can be seen as the 'golden era' of the natural gasification of the British economy, where industry cleaned up its act and cleaner energy was available at ever more affordable prices. According to BRRE figures, domestic energy use grew around 20% per capita between 1970 and 2006, whilst affordability, as measured by energy consumption per unit of disposable income dropped by 50%.

The UK Business Barometer survey of small and medium size businesses in February 2006 suggested that for 66% of businesses, energy costs represented less than 5% of turnover, and for 87% less than 10%.[43] UK retailers spend only about 2 per cent of their turnover distribution and transport costs, according to Gavin George, head of retail at Ernst & Young, whilst a further 2% goes to heating and lighting shops.[44]

While energy prices, with or without the Climate Change Levy, have been rising rapidly since 2005 and business margins are sensitive to these changes, as long as electricity continues to be perceived as cheap relative to overall income, it is difficult to get consumers, businesses and investors to become more energy-conscious and change wasteful habitual behaviour.

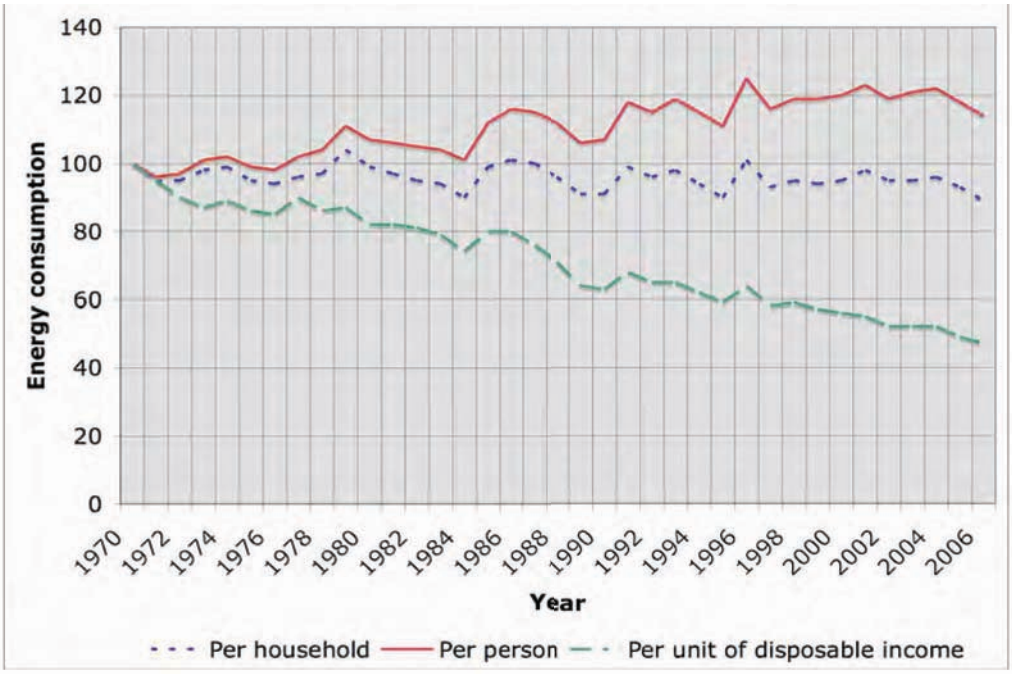

Figure BP 2.3: Domestic energy intensity 1970 to 2006
(Source: Max Lock Centre based on data from Department of Business Enterprise and Regulatory Reform, Office for National Statistics)

[43] UK Business Barometer. 2006. *Survey BB93*. February. <www.ukbb.ac/analyses/06febnews.aspx>.
[44] Webb, T. 2008. 'How the energy crunch hurts UK', *The Observer*. 11 May.

This is critical as around 45% of energy use is dependent on user behaviour.[45] From the case studies we have explored as part of this study, there is often a large gap between the theoretical performance of improvements made possible by retrofitting measures, and the measured performance in practice. This is largely due to the way that occupiers use buildings.[46] Occupier behaviour is thus one of the crucial factors in making retrofitting for sustainability work. One of the key conclusions of this study, therefore, is that there has to be greater targeting of occupiers with information, guidance and advice.

Ironically, perhaps, a short-term energy price shock is likely to have the greatest impact in concentrating the minds of building users on their energy consumption habits and how this could be made less wasteful. In the longer term, however, there is a considerable way to go before the impacts of cheapening energy supply over the past 40 years is cancelled out by energy price rises and there is always a danger of consumers slipping back into bad habits.

The balance of evidence, however, suggests that the era of cheap energy from fossil fuels may soon be over (possibly following shorter-term price falls as the period between successive 'energy crises' gets shorter). This would be at least until a cost effective method of carbon capture and storage for coal is devised (which would certainly add to the cost of energy from this source but buy time until coal reserves were exhausted and/or sufficient nuclear and renewable capacity was available).[47] As far as this study is concerned, an assumption of high energy costs in the immediate future and medium term means that retrofitting measures become more cost effective with shorter payback periods for owners, developers and occupiers.

Ultimately, ongoing higher oil costs means that oil falls out of the equation as a substitutable fossil fuel and becomes reserved for higher value uses. In road-based transport, there are major hurdles to oil replacement through biofuels or hydrogen (or coal-to-liquid fuels).

Future increasing transportation costs have huge implications for economies that have come to rely on cheaper transport and ever increasing levels of movement. One implication is that the process of suburbanisation is likely to go into reverse, with greater reliance of cheaper, public rather than more expensive, individual forms of transportation.

With the current high price of aviation fuel, the trend towards increasingly cheap air travel has been going into reverse. A recession that corrects the upward price trend would in any case reduce the amount of international travel. While the impact on international tourism could be partly offset by the growing number of new middle

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[45] Simon Retallack Senior Research Fellow on Low Carbon Policy at the Institute of Public Policy Research in discussion in 'Week in Westminster'. BBC Radio 4. 15 March 2008.

[46] A typical example of this is in retail premises where investment in improved and more efficient heating and ventilation is dissipated through leaving doors at street level wide open to encourage customers to enter.

[47] If international consensus on reducing carbon emissions were to break down and no agreement follows on from Kyoto, then a dirty coal future for countries with large reserves becomes much more likely, along with rapid and catastrophic implications for climate change. However, it would also be part of a larger free-for-all in which nations retreat into protectionism so energy costs would remain high for those without direct access to coal.

class visitors from the emerging economies, it is difficult to imagine indefinitely increasing international tourism being sustainable in the long term. A combination of these factors is likely to lead in the future to central city areas such as Soho growing in importance in national and regional terms whilst losing some of their market for international tourism.

D. London's CO_2 Emissions

The spatial distribution of London's CO_2 emissions from all activities and the CO_2 resulted from commercial activities is illustrated in the figure in Appendix 7, p.2.