GEA-KM7; Energy Resources for the 21st Century: Contribution by

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INTRODUCTION

Realism over the critical issues of potential energy resources in the 21st century has become a very scarce commodity. This has emerged from a combination of three widely presented, but controversial, hypotheses, viz. first, that there is an inherent scarcity in the world's endowment of energy resources (Campbell, 2003; Heinberg, 2003); second, that a rapid onset of global warming and climatic change will be a consequence of anthropogenically derived CO_2 emissions into the atmosphere (Bossel, 1998; Meadows, 2002); and third, that a set of geopolitical constraints will inevitably inhibit the production of, and trade in, energy (Claes, 2001; Mitchell et al, 2001). Individually, each of these beliefs implies a relatively near-future requirement for moderating the current degree of dependence on carbon fuels; while, collectively, the three concerns not only enhance, but also accelerate the perceived need for a comprehensive switch to the use of alternative energy sources. The objective of this paper is, however, to demonstrate that the moves to economies and societies wholly or largely free from dependence on carbon energy are, in the real world, incapable of being achieved.

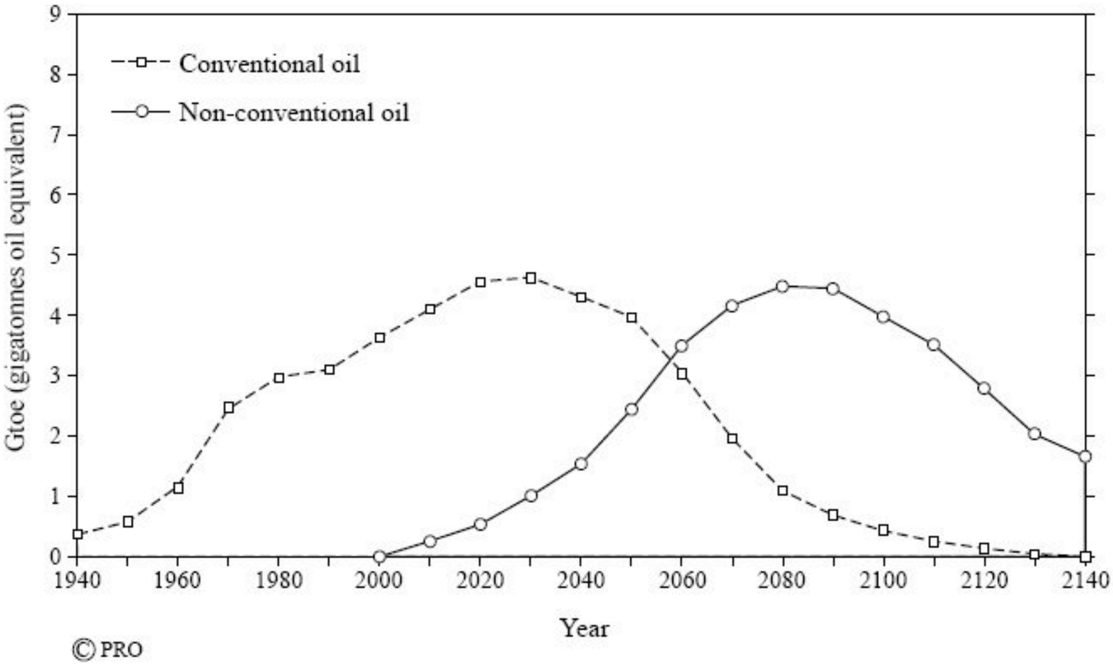
DEMAND LIMITATIONS

For most of the 21st century energy demand limitations will be so significant that little pressure will be brought to bear on the relatively plentiful and profitable-to-produce flows of coal, oil and natural gas. Indeed, continuity in the slowly increasing supply of carbon energy can be achieved, based most emphatically on a very modest depletion of the world's coal resource base (within which proven reserves total some 630,000 million tons – representing almost 140 years' supply of coal at the current rate of use).

There is also an estimated 5000 billion barrels of conventional and unconventional recoverable oil (USGS, 2006), as shown in Fig.1. This coal + oil combination will make for the continuing evolution of an exploitation of the world's carbon fuels for at least the first half of the century in the context of the relatively slow increase in the world's natural gas resources in recent years. From now on, however, plentiful gas resources – partly form conventional, but more significantly, from unconventional habitats – can readily sustain most of the total potential energy supplies required until the very last decade of the 21st century – as shown in Fig.2. this Figure indicates that the world's natural gas industry could, by 2100, be more than five times its size in 2000 (Odell, 2004).

Figure 1

Production Curves for Conventional and Non-Conventional Oil, 1940-2140



The Complementarity of Conventional and Non-Conventional Oil Production: giving Higher and Later Peak to Global Oil Supplies

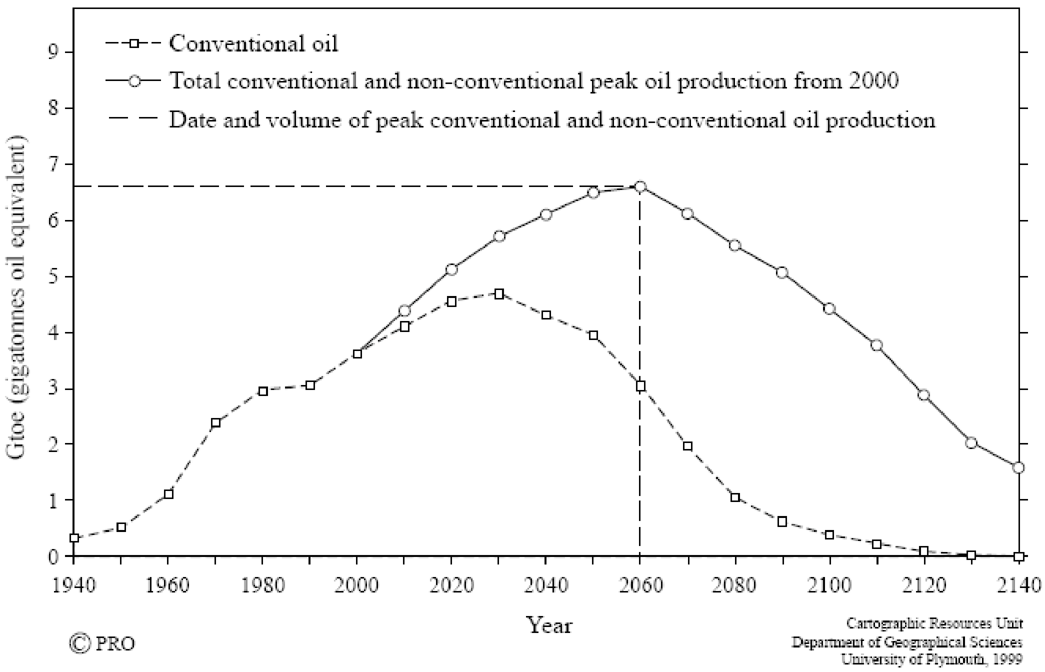
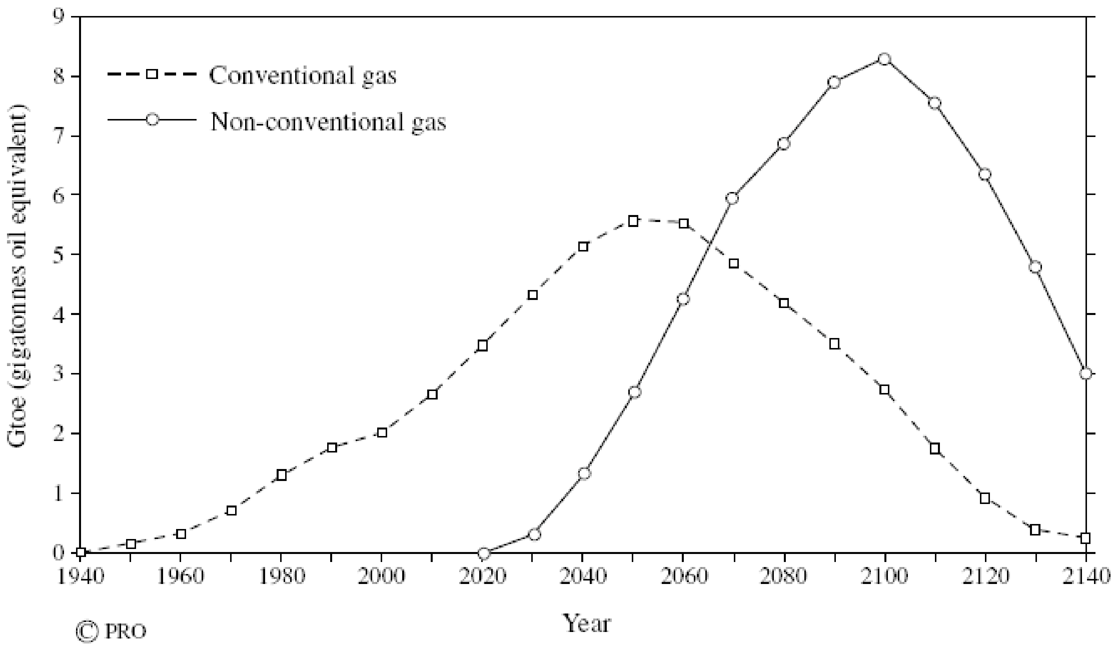


Figure 2

Production of Conventional and Non-Conventional Gas, 1940-2140



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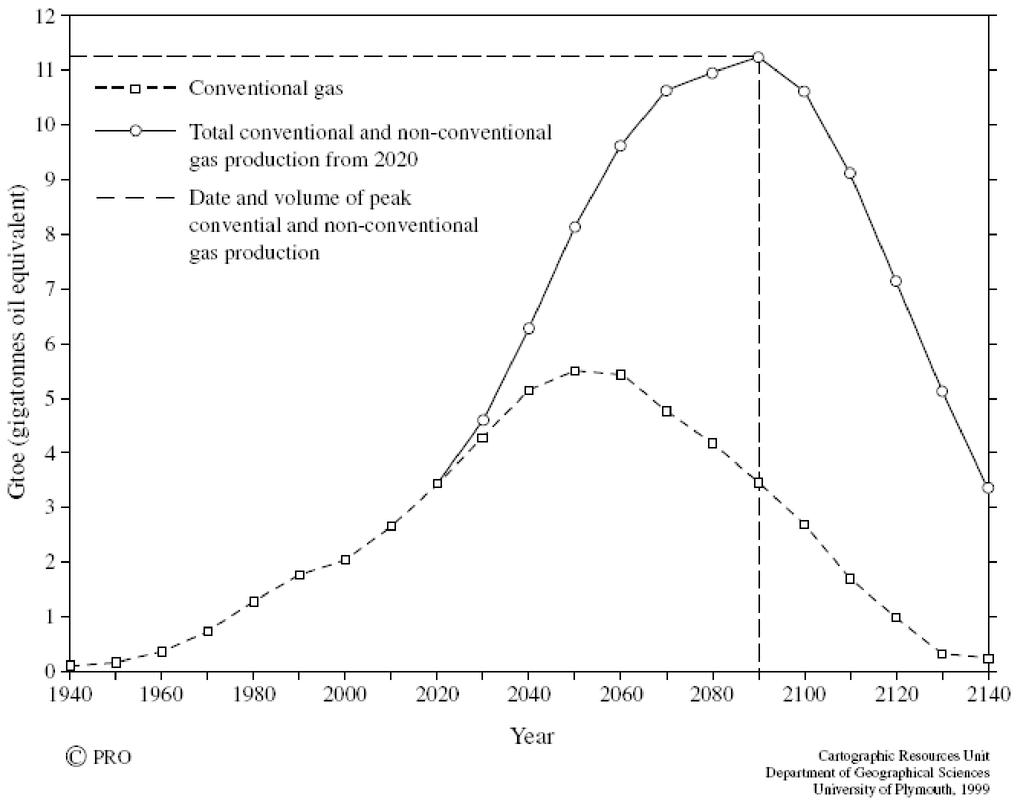


Over the 21st century as a whole a total of some 1660 Gigatons (= 1660x 10^9 tons) oil equivalent of carbon energy will be produced and used, compared with a cumulative total in the 20th century of just under 500 Gigatons. This more-than-three-fold increase in the use of carbon energy in the 21st century reflects not only the bountiful nature of the world's endowment of carbon energy fuels, but also the general willingness of the nations which are rich in coal, oil and/or natural gas to accept the depletion of their "natural" resources, in return for the economic growth it generates for the countries concerned and the rising incomes it secures for their populations.

SUPPLY SIDE ISSUES

It also requires continuing managerial and technological achievements on the part of the multitude of global regional and local entities which will be responsible for the extraction, the transportation and the processing of the world's energy resources. The fundamental mutuality of the interests of the very many parties already involved in such activities – albeit with temporary disturbances between them arising from economic and/or political difficulties (as over the past 100 years) – will virtually ensure supply continuity at the levels required by demand developments. In this set of defined circumstances for the exploitation of carbon energies, the concept of "resource wars" (Klare, 2002; Kleveman, 2003) becomes invalid, as such phenomena are likely only in the context of a terminal scarcity of coal, oil and/or natural gas. Such scarcity is excludable for the 21st century, except temporarily from time to time, on a local or regional scale.

Neither is the carbon-energy production industry a serious, or even a relevant phenomenon with respect to the issues of global warming and climate change (Kinninmonth, 2004; Sarokhtin, 2007): except under the close-to-unthinkable circumstances of very large scale and long-continuing releases of methane (natural gas) to the atmosphere from the production and transportation infrastructures of the industry. This could occur only in the context of the generally expected markets for gas failing to materialise, so that the companies and other entities involved have neither the will, nor any commercial motivation, to inhibit such a development.

Ironically, the only possible cause of such an occurrence would be a rapid and low-cost expansion of renewable energy sources, so that the 'bottom' traumatically dropped out of the natural gas markets. In reality, neither the generally modest speed of constructing renewable energy production plants (viz. windmills, solar power installations, tidal or wave power driven generators, biomass fuelled electricity production etc), nor the immediate and near-future ability of such plants competitively to produce alternative (renewable) power can generally and effectively challenge the cost of electricity made from gas – or, indeed, from coal or oil. It is these negative attributes of most renewable energy resources which make their expansion at a rate whereby renewables could meet even the <u>incremental</u> demands for energy in the first half of the 21st century well nigh impossible.

This inability has already been effectively demonstrated in the world's richest and most technologically orientated countries since 1990; the base year from which the Kyoto Protocol required their reduced use of carbon fuels whereby the volumes of their CO_2 emissions be reduced. On the contrary, their collective use of 3525 million tons of oil equivalent in 1990 (from a melange of oil, gas and coal) increased to 4715 million tons by 2005. In marked contrast with this 1190 million tons oil equivalent rise in carbon energy use, their use of renewables increased by only 180mtoe. Of this, moreover, 150 mtoe was accounted for by nuclear power – a pseudo-renewable energy source. But the supply of nuclear electricity has since fallen away, given that the small number of new stations under construction or currently planned will not even succeed in replacing the output of the stations which are scheduled for decommissioning in the short and medium terms (Grimston and Beck, 2002).

To date, moreover, the status of other non-renewable energy producers (except for hydro-power) remains that of an "infant industry". An industry, that is, that is incapable of sustainable growth without either a continuing input of state subsidies to reduce production costs or the willingness of consumers continuously to pay a premium price – over that for carbon energy – for so-called "green" energy. Thus, even for the world's already "well-energized" economies and societies – still more than 83% dependent on carbon fuels and with half of the remaining 17% derived from a nuclear power industry now in decline since 2006 – there are no realistic prospects of their incremental annual demand for energy being totally met from renewables, let alone for the latter being capable of substituting the countries' existing use of carbon energy!

Unless, that is, the governments of these countries stipulate and require energy markets which are so transformed. The supply disruptions and the populist protests against the burdens, of both additional capital and running costs which would consequently emerge, put such a radical policy out of reach. Such a change is thus a generally unlikely development in the overall energy economies of these countries, while, in particular, it is an impossible change for the near-exclusively carbon-fuelled transportation sector of their economies. Over 50% of global oil use and about 22% of energy use were already concentrated in this single sector in 2000 – and the percentages are still increasing (Mitchell, 2001).

Thus, in spite of most of the rich world's countries' so-called Kyoto Protocol "commitments" to reduce CO_2 emissions, future progress towards the achievements required remains highly improbable(IEA, 2002; Jean-Baptiste, 2003). At best, progress in reducing emissions will be slow until 2020, but with some hope thereafter of more rapid progress. This development will most likely be mainly associated with an increasingly large-scale sequestration of CO_2 captured from the combustion of carbon fuels. Technological developments, effective management and the falling real costs of sequestration will make this a more acceptable and, moreover, a financially less costly way to achieve emissions' reduction targets than that which could be achieved from constraints on carbon fuels' use with its consequential adverse effects on economic growth and on public opinion. Offsetting the costs of sequestration will, however, directly motivate attempts to enhance energy use efficiency and will also stimulate changes in economic and societal structures designed to reduce energy requirements. Albeit with a decade or more delay, one may also reasonably expect similar developments in the until-recently centrally planned economies of the former Soviet Union and Eastern Europe.

These above two sets of countries – with only one-fifth of the world's present population – still currently account for over 60% of global energy use. But, a combination of their generally relatively low rates of population growth and their ability to achieve higher efficiencies in energy use will continue to reduce their share of the world's use of energy – and, in due course, could eventually lead to the stabilisation of their CO_2 emissions: providing it is accompanied by the sequestration of their CO_2 emissions on an increasing scale.

THE ROLE OF DEVELOPING COUNTRIES

Under these emerging circumstances the world's developing countries – already with 80% of the world's population and with the percentage still growing – will play a rising relative role in both global energy use and in CO_2 emissions. Indeed, as with most other attributes related to the process of development, these countries will need to use increasing amounts of energy, given that, on an average per capita basis, they currently use only one-eighth of that used in the rich counties of the world. This "natural" phenomenon of rising per capita energy inputs to the world's poor countries' economic and social systems is, however, possible only by their increasing their production and use of low-cost carbon fuels. The alternative renewable sources of energy are – to an even greater extent than in the developed countries – simply too-high cost, except in niche markets largely unrelated to industrialisation, urbanisation and motorisation (Anderson, 2001).

Thus, the future global energy needs of the developing world will inevitably be low-cost coal, oil and natural gas – albeit increasingly used at the higher efficiencies already achieved in the rich world. This will occur in preference to the generally higher capital-cost renewables such as are now under development in the OECD countries with subsidies from both international organisations; for example, the International Energy Agency and the European Commission, and from national governments (European Environment Agency, 2002; European Commission, 2003; IEA, 1997). Given that higher per capita incomes, enhanced standards of social welfare and significant spatial mobility which cumulatively accrued over the many decades from the late 18^{th} century to the present day in the countries early to industrialise and urbanise were, in large part, the result of access to carbon energy sources at low prices; then similar opportunities that are now opening-up to the world's other countries and to their rapidly growing populations cannot be denied to them. Unless this was done in the context of massive subsidies from the 'north' to the 'south' whereby the higher costs – both financial and temporal – which the production and use of renewable energies involve were fully offset. This is highly unlikely.

Meanwhile, demographic trends will locate the overwhelming percentage of the close-to-three billion more people expected to inhabit the earth by 2050 in the developing world. All of these should expect, as a matter of course, to have access to enhanced supplies of energy, in general, and to electricity, in particular: together with the estimated present up to two billion people in the developing world who are still without access to domestic electricity (Anderson, 2001; IEA, 2003a).

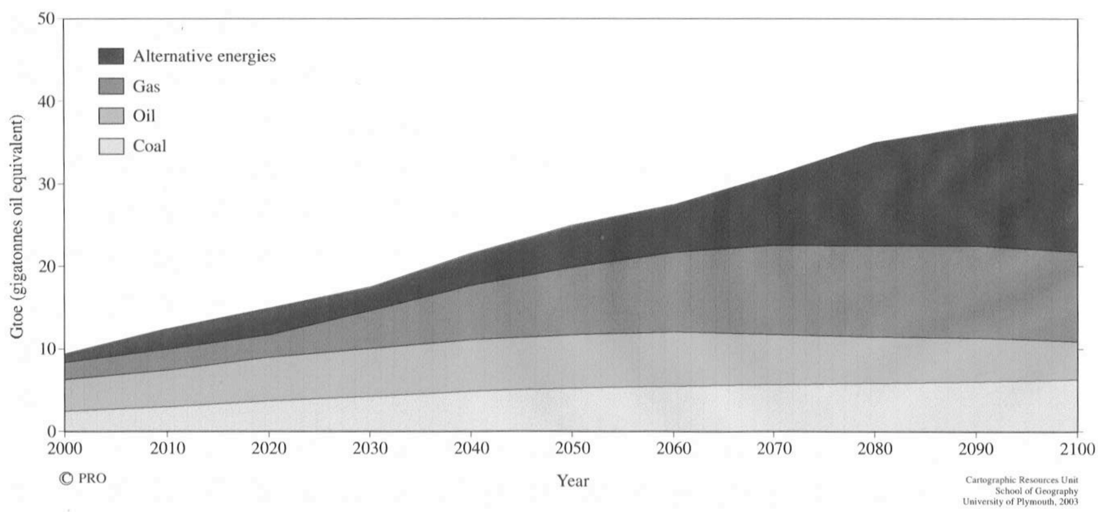
ENERGY USE AND SUSTAINABILITY

This necessary – rather than the simply desirable – completion of access to electricity for all the world's householders is a more appropriate and positive form of sustainability than that which most policymakers in the world's richest countries present as their top priority, viz. the achievement of global sustainability through the containment and the relatively near-future reduction of CO_2 emissions to the globe's atmosphere, so that their hypothesised fears for global warming and climatic change can be eliminated. Quite apart from continuing doubts over these hypothesised links (Gerholm, 1999; Bradley, 2003; Kinninmonth, 2004; Sarolhtin, 2007) and the potential developments in the relatively near future of technologies which can significantly reduce and eventually eliminate the growth in atmospheric CO_2 at a cost well below that of switching from carbon fuels to renewables (Williams, 1998; Freund, 2002), there can be neither economic nor ethical justification for actions which delay or even obstruct the poor world's needs for sufficiency of energy to secure development and enhanced living standards. Most of the people concerned live in, or will be born into, countries that can only achieve such improvements through the exploitation and use of coal, oil and/or natural gas (Odell, 1984, 1990 and 2004; Greenpeace 1997; IEA, 2003 and 2004).

Thus, instead of the high profile demands of the proponents of the Kyoto Treaty through heavy-handed and urgent pressures to secure the substitution of carbon fuels around the world by the direct and indirect use of solar power, realism and necessity firmly relegates the enhancement of the presently low percentage contribution of renewable energies to the total energy supply to the second half of the 21st century. Renewables, as shown in Figure 3, will, by 2050, still contribute less than 20% of total global energy supply (compared with a little over 10% in 2000 – excluding non-commercial traditional biomass in the world's poorer countries). Such a near doubling of renewable energy's importance by the mid-21st century can be defined as an organic growth rate, rather than one forced through by policies which require fundamental societal changes and the denial of the use of low-cost carbon fuels. The additional use of renewables will, thus, be concentrated mainly in those countries which are severely constrained, or even or even completely devoid, of exploitable indigenous sources of carbon energy, so that renewables' exploitation could well be an imperative for their advancement. Examples of such countries are Belgium, the Czech Republic, France, Sweden, Germany and Belarus in Europe; Chile, Paraguay and Uruguay in the Americas; Japan, the Philippines, South Korea and Turkey in Asia and a number of countries in sub-Saharan Africa. For these countries near-future enhanced security of energy supply, rather than concern for long-term climate change possibilities, is of the essence (Thomas and Ramberg, 1990; Randall, 2002).

Figure 3

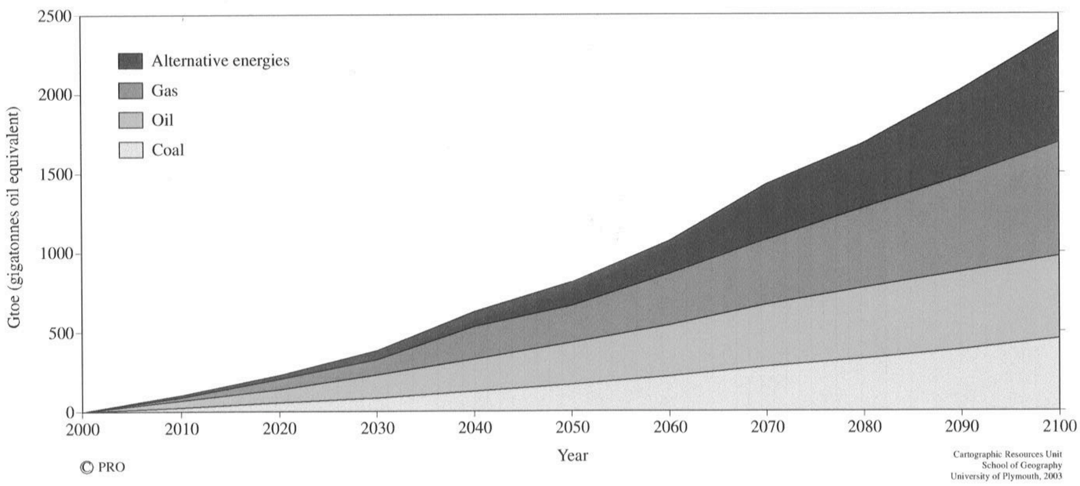
Trends in the Evolution of Energy Supplies by Source in the 21st Century



Post-2050, however, following the peak of global oil production and in the context of a possible reduction in the growth rate of the natural gas industry, there will be a market-orientated widening of interest in renewables, especially in the rising number of countries in which indigenous carbon fuels become relatively scarce and more expensive. As a result, renewables could, by 2080, account for about 25% of global energy use; and for over 40% by 2100. Nevertheless, even then, carbon fuels will collectively still be the more important component in energy supply. But by then the world will have become emphatically marked by significant regional and county-by-country variations as a function of highly significant geographical variations both in the availability of carbon fuels and of renewables. Cumulatively over the century, as shown in Figure 4, renewables will supply just under 30% of the total energy used.

Figure 4

Cumulative Supplies of Energy by source in the 21st Century



THE CONTINUITY OF ENERGY SUPPLY SYSTEMS: AND ITS IMPLICATIONS

This predicated division of the 21st century global energy market between carbon fuels and renewables, in a world in which the population has stabilised at about nine billion, of which the overwhelming majority are linked into gas and electricity systems, represents in essence a continuation of the organisation of the energy sector in a way which has already become the norm in the world's richer countries. With the indicated close-to-four-fold increase in total annual energy use over the century (see Figure 3), but with an increase of only about 50% in the world's population, average per capita use of energy will increase by almost 2.7 times. This generalised statistic does, however, conceal a wide range of changing per capita energy use variations across the world, viz. from close to zero or even negative increases in the world's already energy intensive counties (viz. the current OECD countries minus Mexico, plus the formerly centrally planned economies of the 1950-1990 Soviet bloc), to multi-fold increases per head in the populations of today's poorest under-developed countries. In almost all cases, however, the efficiency of energy use in terms of the GDP generated by a unit of energy input will certainly have increased.

Nevertheless, the indicated inevitability of continuing increases in the production and use of carbon energy sources seem likely to cause consternation in the ranks of the believers in a causal link between CO_2 emissions from the combustion of such fuels and global warming/climate change. For those pessimists who visualise only adverse results from such developments (Bradley, 2003), this paper's conclusions incorporate only two "saving graces"; first, that only a two-and-a-half-fold increase in carbon energy use is indicated, compared with a more than five-fold increase predicated by the IPCC's basic scenario (IPCC, 2001); and, second, that the forecast strong increase for natural gas in the mix of carbon energy sources will serve to reduce CO_2 emissions by about 10% from what they would have been, had the years' 2000 division of the carbon energy market remained the same throughout the 21st century.

The conclusions of this study for CO_2 emissions in 2100 are thus indicated at 2.6 times their 2000 level; self-evidently an" unsustainable" proposition for the global warming lobbyists (Bossel, 1998; Bartsch and Müller, 2000; Hoffman, 2001; Jean-Baptiste, 2003). Given a widely-held acceptance of the latter's claims and warnings, then the only way out of the impasse created by the inevitability – and the economic and social desirability – of increased carbon energy use as argued here, lies in an immediate start to implement measures to sequestrate the CO_2 produced by combustion (Freund, 2002). The costs of this procedure will, given the difficulties ranging from the technological to the political which remain to be resolved (Maritus, 2003; Pachin, 2003; Torp, 2001), necessarily but modestly increase the costs – and hence the price – of carbon energy: but this price-impact on users will have a positive feed-back effect on the rate of enhancement in the efficiency of carbon energy use and will thus, in due course, serve to reduce the rate of growth in the demand for energy.

Under these circumstances both the volumes of carbon energy required over the century could turn out to be significantly lower than this study suggest, while its share of the total energy market would be below the 70% calculated (Figure 4). Nevertheless, the 21st century's energy economy will remain dominated by carbon fuels, with much of their supply and use orientated to environmentally more friendly modes of production and transformation: most notably in natural gas' potential use for the production of hydrogen, initially for inputs to fuel cells, costs permitting (Anthrop, 2003), and, later, for the direct use of the hydrogen in both static and mobile outlets (Griffiths, 2001; Hoffman 2001; World Petroleum Congress, 2002; European Commission, 2003).

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