Our Energy Challenge: securing clean, affordable energy for the long term

A submission to the Department of Trade and Industry

On behalf of the of The Worshipful Company of Fuellers

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All figures given in this paper are indicative, using best-available data. We give sources wherever possible.

1. Introduction

The Worshipful Company of Fuellers welcomes the chance to respond to the important new consultation, “Our Energy Challenge”. We are a modern, technically-oriented City Livery company formed under our current name in 1981, although our roots date back to the Woodmongers and Coal Sellers Company of 1376. Our members range from senior managers and proprietors to expert specialists in all areas of the energy industry as well as others with an interest in this field and in the City. We have members who are working in or retired from major oil, gas and coal producers, in firms that retail electricity and gas and that generate electricity and in National Grid-Transco, as well as members who bring the perspective of major consumers of electricity, of gas and oil wholesaling, relevant aspects of the military, and those with interests in academia, in small and medium firms including energy consultancy, renewables and, for example, oil and gas installation design. We also have close links to electrical appliance manufacturers through our sister livery company, the Worshipful Company of Lightmongers, and to the Worshipful Company of Engineers.

We are acutely conscious, from this diverse professional membership, that as a nation we must have control of secure, economic and low-carbon energy supplies. When Japan lost most of her oil imports in 1972, her GDP dipped 10% in one year. Loss of access to energy is crippling to an advanced economy. It must never happen to the United Kingdom.

We hope that our contribution by way of this response to the consultation will be helpful given the broad and relatively independent perspective that we hope to bring.

2. Executive Summary

We welcome the 2006 Review. The UK and world energy landscape has changed decisively and enduringly in recent years, and the work of the PIU from 2001 that led to the 2003 Energy White Paper, has become in need of quite fundamental review. It is clear that the real and dangerous climate-change risks we face as a result of CO_2 emissions cannot be ameliorated by energy efficiency and renewables alone. Mass behavioural changes - to realise a cut in demand - are hard to achieve. In fact, government plans include the building of 5 million new homes by 2026, which would increase energy demand enormously (including the need for extensive desalination plants requiring up to 1000 TWh of energy), and "DIY" home-air-conditioning units have become widely available in retail outlets in the last three years – this could significantly increase annual demand. Energy efficiency regulations proposed for new-housing were actually watered-down last year.

Growth in energy terms from new-build in wind power last year in the UK was just a quarter of our electricity demand growth, whilst our nuclear power stations stand to close and be replaced by gas-fired generation. We hesitate to mention uncontrolled growth in CO_2 emissions from the road and air transport sectors, where government policy is not to manage, but to meet this unsustainable level of demand - by building more major runways.

Prices are at a level that has doubled fuel poverty amongst vulnerable customers since 2003, and has already put sections of UK manufacturing industry out of business and cast a serious shadow on many more.

Compelling evidence has been mounting almost by the day that it would be prudent to minimise our national reliance on imported gas from unstable and unreliable regions, and that we cannot rely on gas flows from Europe when price differentials should mandate that interconnector flows, or ship movements, take place.

The lack of long-term, equitable carbon pricing is preventing finalisation of investments in almost all major generation projects including CCGTs, and it is not clear that the market alone can provide much-needed strategic gas storage. The market cannot provide replacement-nuclear without a clear "green light" from government, which must include the removal of artificial planning/design certification barriers, a clear and totally equitable UK framework of long-term pricing for carbon.

UK governmental funds devoted to research into clean coal, sequestration, hithane, and "generation IV" nuclear fission technology are all well below the necessary levels to enable the UK to play her part on the world stage in alleviating global warming and indeed developing and applying commercial technologies.

Monies collected from customers by government agencies under the non-fossil-fuel arrangements, intended to support zero-carbon generation, will amount to between £500m and £1billion by 2008 and yet are not being released for zero-carbon generation research.

Fuellers are acutely conscious that as a nation we must have control of secure, economic and low CO_2 emitting energy supplies and that any loss of energy would be crippling to our advanced economy.

We believe that there is no room for error and therefore that all options should be enabled both to secure our long term energy requirements and to minimise our national CO_2 footprint. We shall, as a nation, need replacement-nuclear, clean coal, coal gasification, carbon sequestration, renewables, and real solutions to seriously curb runaway growth in CO_2 emissions from road and air transport.

The new advance design licensing process should give rise to conclusive and full pre-licensing (or rejection) / certification of replacement nuclear designs, and hence a conclusive certification of suitability (or otherwise) – it should **not** merely be a general, inconclusive technical review. This latter would be a waste of resource, and actually hinder a site-specific application – not that any applications are likely until the barriers are removed.

The UK's solid fuel inheritance should be properly used, and we have made detailed suggestions in this response that could aid in this – including the removal of the discriminatory "presumption against" when assessing surface-mining planning applications.

In conclusion our specific recommendations are as follows:-

- The replacement of the present Renewables Obligation and Climate Change Levy with a unified, equitable, strong LONG TERM carbon valuation that would allow sequestration, nuclear and renewables options to compete alongside clean coal and CCGTs on a perfectly equal basis. Carbon should be priced into the market on a full-lifecycle basis

- The proper use of our solid fuel inheritance

- Government sponsored strategic gas storage

- The removal of present artificial planning/design certification barriers that inhibit replacement nuclear generation

- A detailed examination of all current legislation to reduce the present unacceptable waste from the inefficient and inappropriate use of energy along with incentives for "smart metering" – so householders and businesses can see the real-time costs of their energy consumption.

- Allocation of Government research funding into
  - Clean Coal Technology and Coal Gasification
  - Carbon Sequestration
  - Hithane
  - Nuclear Fission Technology
  - The continued development of Renewable Technologies
  - The reduction of CO_2 emissions from road and air transport

Our full submission now follows. We begin with a detailed review of the reasons why the present review appears necessary to us. We then address the key technical issues in detail, before presenting a summary of our recommendations

3. What Has Changed Since 2003?

We have studied the aims of the last Energy White Paper (EWP) in 2003 and the significant developments that have taken place, or in some cases developments that were perhaps optimistically anticipated that have not taken place, since then. We do strongly believe that there is a need to take a fresh look at the matter, and that UK Energy Policy in the absence of this review would have been set to fail on all counts – on energy costs, on security of supply, and on reductions in total UK carbon dioxide emissions. In essence, these would seem to be the elements that indicate a fresh, fundamental policy rethink is needed now – we list them as capital-lettered paragraphs, below. The first four points relate entirely to gas, naturally a key matter as the policy framework set out in EWP would have us at least 80% reliant on natural gas for electricity generation by 2020, and 90%[1] of that gas would be imported in the longer term, either ultimately from Russia or ultimately from the Middle East, although in the short to medium term at least a portion of our supplies will come from Norway, a more stable supplier.

A. Gas supplies from the UK Continental Shelf have declined somewhat faster than most parties' expectations.

B. Confidence that can be placed in the security of economic gas supplies from Russia into Europe is now much less. Although there had been previous interruptions since 2000 of Russian gas supplies into Georgia and into Belarus, the extent of interruptions has grown rapidly recently and confidence in those supplies for the future has accordingly diminished. Since the beginning of 2006 we have seen interruptions of Russian gas supplies to Finland, Italy, Moldova, Georgia, the Ukraine, Armenia[2] and the Baltic states. The interruptions of contracted Russian gas supplies to Italy have taken place over a number of weeks and appear to be ongoing sporadically at the time of writing. There was clear evidence of Russian government involvement in the breaching of gas supplies to the Ukraine, which is now supplied on terms far inferior to those to which gas is supplied to Belarus, it is being suggested that the price the Ukraine now pays for her gas supplies is so high that the deal will not survive the year because she cannot afford it. On 3rd April 2006 The Wall Street.Journal (Europe) reported a five-fold gas price increase demanded by Russia of Belarus following the re-election of the pro-Russian leader of Belarus. The UK faces the prospect that the Russian state gas firm, Gazprom, may be permitted to take over Centrica and thereby gain further control of our gas supplies through Centrica's ownership of our Morecambe Bay gas field and its stakes in all our LNG import facilities and some of our storage. This would be undesirable – as a nation, we must control our energy supplies, or at least import them from reliable partners. There have been a number of attempted and actual business-related deaths in recent years affecting figures in the Russian energy industry[3], other Russian business

[1] "Our Energy Challenge"; DTI Energy Review Consultation Document; January 2006
[2] http://news.bbc.co.uk/1/hi/world/europe/4641756.stm
[3] In 2005 these included an attempt on the life of Chubais, head of the largest electricity firm, and the conviction of Pichugin - head of security at the largest oil firm - of commissioning two murders

sectors and of opposition politicians[4] as well as the head of the Russian anti-proliferation regulatory body. Russia's annual homicide rate per million, at 200, is 30 times that of the UK and is the second-highest in the world - over his lifespan, a Russian has a one in sixty chance of being murdered at current rates[5].

The Fuellers note that in the MORI poll of the public on energy matters in October 2005, over 96% of those expressing an opinion said (rather unrealistically, but we should certainly recognise this is the public's very clear *aim*) that "The UK should aim to be self sufficient in energy".

Strongly agree	Tend to agree	Neither agree nor disagree	Tend to disagree	Strongly disagree	No opinion
50%	33%	9%	2%	1%	6%

- 1,931 British adults were surveyed, representative of the population
- Fieldwork was carried out by Ipsos MORI between 21st and 27th October 2005
- Where results do not sum to 100%, this may be due to computer rounding

In consequence of greatly-increasing future reliance on imported gas for power generation, UK electricity security is projected to go from being the best in the G8 to the worst within two decades[6].

C. There are concerns about liquefied natural gas (LNG) supplies. It had been hoped that having import facilities in place would mean that ships full of liquefied gas would land and gas would naturally flow in to the UK when UK gas prices were high. In order to help firms fund the new infrastructure the EU and UK authorities freely gave waivers from the parts of the EU Gas Liberalisation Directive relating to "third party access", placing confidence in those controlling the new assets that they would ensure that the UK received the gas it required. This has simply not taken place[7]; the landing jetties at Grain have often stood empty. Initially many commented that BP and Sonatrach were not making the facilities available to others in good time, and that the "use it or lose it" provisions were not being enforced by Ofgem. This may well be so, but the situation is now gravely exacerbated by the Spanish government's new law setting the Spanish gas imbalance cashout price at 50% *above* the higher of UK and USA gas prices, thus ensuring that the LNG tankers, at times of international shortage, are almost sure to go to Spain, in preference to the UK. This is exactly what has been reported as happening in the winter just gone.

[4] www.guardian.co.uk/worldlatest/story/0,,-5648932,00.html;
[5] www.sasi.group.shef.ac.uk/publications/2005/shaw_tunstall_dorling_murder.pdf
[6] "Comparison of the Security of Electricity Supplies in G8 Countries, 2004 to 2024" Prof J H Gittus; Power UK, March 2004; repeated in updated form in Power UK February, 2006, and delivered as talk to CBI/TUC conference 28th February, 2006
[7] "Winter 2005/06 Experience and Outlook"; Ofgem presentation; Ofgem "Winter to Date" Seminar, January 2006

D. Competition in Europe is not working well, and the UK would appear to have a need to look after her own interests. Spain and France have been permitted, effectively through direct government intervention in the markets, to protect their national energy firms (Suez, Endeza) from energy firms in other EU member states (ENEL, e.on). There is a real concern that the EU will not take action against the governments of France and Spain over these anti-free-trade transgressions, and that markets and business areas which in the UK are open, such as energy, airports, docks, and other important facilities, may not become open in other EU states. The UK, then, must look to her own interests and not make unrealistic, idealistic assumptions about our fellow-Europeans.

E. It has been noticeable that there has been little correlation between the UK-continental gas price differential, and UK-continental gas flows. Specifically, gas has not been flowing to the UK when it ought. There have been suggestions by, amongst others, Jonathan Stern (FT, 1/3/2006), that continental governments have more control over continental gas storage facilities, than the UK has appreciated (and certainly, than is the case in the UK). It is suggested that continental governments have mandated to continental energy firms that continental gas storage facilities were to remain filled to a high level going into the predicted cold winter, even when profitable exports to the UK would have been possible, to secure the supply-continuity interests of continental consumers. This was apparently at the expense of both profitable trade with the UK and the supply-continuity interests of UK consumers. Again, it might appear that relying on our continental cousins to enforce strict free trade may be unrealistic – continental governments look to matters in a strategic manner that is perhaps neglected by our own. We note that the UK capital markets have not only invested in new gas import infrastructure on a "slightly later than just-in-time" basis, but that they have only felt able to invest in relatively minor new storage facilities. This leaves the UK critically reliant on the Rough gas storage facility, especially as our UKCS gas supplies (and the opportunities to flex those) decline quite rapidly now. Whereas continental countries on average have gas storage equal to 56 days of their national demand, the UK figure is just 9 days' worth of peak demand[8] and 14 days of winter average demand[9]. This UK storage is moreover unduly concentrated in just one facility – Rough represents 80% of UK storage capacity by volume, but it has been broken since a minor explosion and subsequent fierce fires occurred on 16th February 2006, and is now out of service whilst 30 km of cables on the platform are replaced - until at least June 2006 for injections, and October 2006 for withdrawals. Had it broken down at the beginning of the winter, rather than at its end, the consequences would have been greater, including compulsory disconnections of firm demand.

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[8] House of Lords report "Renewables practicalities" July 14th, 2005

[9] "The Future of UK Gas Supplies"; Parliamentary Office of Science and Technology; POST note 230; October 2004; and www.publications.parliament.uk/pa/ld200304/ldselect/ldsctech/126/12604.htm para 2.5

F. The data on energy demand is also pessimistic. Contrary to the idealistic expectations of the 2003 EWP, UK gas, electricity, road and air transport-related demand have all continued to grow at historic rates. Part of the reason is that policy has been weak: the energy efficiency aspects of the recent new building regulations were watered-down under pressure from ODPM. Indeed, developers of new flats to this day do not, as a matter of course, fit condensing boilers, and aerial infra-red photographs sometimes show considerably more heat leakage from *new* commercial buildings, than from much older ones.

The Worshipful Company of Fuellers notes that policies of successive governments since the 1980s have been notably unfriendly in fiscal and legal terms to marriage, and hence to the traditional, enduring family unit[10]. The resulting social breakdown is leading to lower average occupancy per home. Partly for this reason, and partly due to net immigration, the UK government is now encouraging the building of about 5 million new homes by 2026 in England alone, according to a report issued on the 15th March 2006.[11]

Upon occupation, the 5 million new homes will naturally require power, heat and light, and bring unprecedented new energy requirements for desalination plant, to provide their water needs.

Road and air transport appear completely out of control with UK energy growth figures of around 4.4 and 7.7 % for energy consumption in these two transport sectors respectively. Average UK motor cars now achieve less fuel economy than they did in 1972, as people choose larger, more powerful engines, with a higher proportion than before outside rural areas of much larger vehicles with four-wheel-drive.

The trend of retail premises to leave their lights on all night is uncontrolled and continues to grow, and oil refineries continue to "flare" excess methane from the "cracking" process[12].

Moreover, the UK government has not been willing to tackle aviation, where aviation fuel is not taxed and consumers are not paying for their environmental externalities. Government policy on aviation demand is simply to meet it by constructing new runways, so there isn't even any price-rationing arising from the cost of, or other limitations on the

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[10] p.113 of the new book "*Family Policy, Family Changes* published 22nd March 2006 by Civitas: "The lone parent is the family form preferred by the UK tax/benefit system"; p.112 : "'There is a tacit anti-marriage agenda in … policy-making"

[11] www.telegraph.co.uk/news/main.jhtml?xml=/news/2006/03/15/nhomes15.xml&sSheet=/news/2006/03/15/ixhome.html

[12] Flaring overseas is worse : the World Bank estimates that the annual volume of natural gas being flared/vented is about 100 billion cubic metres, equal to the combined annual gas consumption of Germany and France. If the gas flared in Africa today were used for power generation, it could produce 200 Terawatt hours (TWh) of electricity per year, or about 50% of the current power consumption of the African continent and more than twice the level of power consumption in sub-Saharan Africa (excluding South Africa).

availability of, runway "slots" (in the absence of any more direct environmental pricing).

The promise of micro-CHP has not been realised, with a recent Carbon Trust report showing that of 40 domestic installations of micro-CHP units, in 1/3rd of cases net CO_2 emissions from that house were higher, in 1/3rd of cases net CO_2 emissions from that house were the same, and in only in 1/3rd of cases were net CO_2 emissions from that household, actually lower[13]. Expectations should be realistic, and it may appear that there will always be a role for centralised, large-scale generation with its economies of scale and better scope for pollution control. In any event, the possibilities of new distributed or micro-generation running on any fuel other than (imported) gas, appear extremely limited, and so they would merely add to our national gas-reliance dilemma if they succeeded. Indeed, building regulations discriminate against wood-burning capabilities in new homes.

G. Around 500MW of wind capacity is currently being built annually in the UK[14]. Assuming a typical load factor of around 30%, this equates to an average of around 150MW of electricity delivered, compared to 625 MW or so annual electricity weather-corrected demand growth. Thus the growth in UK wind energy generation, a key component of renewables growth, is just 24% of the growth rate in UK electricity demand.

The best that the most enthusiast advocates of renewables are suggesting is possible, at the cost of £1billion per year, is that renewables might ultimately just achieve 20% of the UK generation mix, thereby *not* managing to even replace closing UK nuclear plant, whilst electricity demand will of course have grown and will need to be met by other plant (CCGTs under the current energy policies). In fact, by contrast, we should actually be radically increasing the zero- CO_2 proportion of our generation fleet, both to meet the government's target of a 60% reduction in CO_2 by 2050 in relation to the electricity sector taken in isolation (in spite of growing electricity demand), and to offset the galloping growth in CO_2 emissions from UK transport, particularly air transport with air transport-related CO_2 emissions currently growing at 7.7% a year (with no policies in place to ameliorate that growth and no sense of genuine political will there, either). Commentators such as John Bower have remarked that even with an all-zero-CO_2 UK generation fleet by 2020, the UK could not meet her CO_2 aspirations due to demand growth especially in transport.

[13] The report showed that preliminary results for micro-CHP are not as encouraging as hoped. Only a third of micro-CHP trial installations decreased emissions - a third increased them - remainder showed no discernable difference (with respect to standard gas boiler/grid electricity supplies). Performance of small scale CHP in business seems to be stronger. Domestic heating and electrical load may coincide quite well in aggregate, but not at an individual level - so units tend to spend time cycling inefficiently, with significant import/export due to unmatched load. NB these are initial results based on a small sample size (40 installations) so could yet change. Net carbon impact is assessed with reference to the current average grid mix - if grid emissions improved (more renewables/nuclear/CCS) the carbon benefits of micro-CHP would be even lower.

[14] www.bwea.com/ukwed/operational.asp

H. It is now very apparent that global warming is likely to occur. The evidence for the concept of "positive feedback" accelerating climate change, due to a range of effects such as the release of methane trapped in melting ice floes and the "arid-isation" of growing currently-green land areas, and other adverse exacerbating effects such as loss of rainforest and other carbon sinks, is also compelling and most unfortunate. The government's 60% reduction target by 2050 was based on assessment by the Royal Commission on Environmental Pollution of the action needed to limit global average temperature rise to 2ºC. This was established as corresponding to a CO_2 level of 550ppm. However recent work by the IPCC, acknowledged by DEFRA[15], indicates that the figure at which we aim to stabilise CO_2 to achieve this 2ºC limit on global average temperature rise, ought to be closer to 450ppm, and therefore our national 2050 CO_2 reduction target, extremely demanding and very hard to achieve though it is, may actually be too lax. We note that – on current policies – UK emissions in 2020 will be between 144 and 148 MtC[16]. This is some 30MtC higher than the level which the 2003 White Paper indicated would represent "real progress" towards the 2050 target[17].

I. It is also apparent that the UK's CO_2 emissions are less than one per cent of global human-related CO_2 emissions, and that many other nations such as China, India, and the continent of Africa are likely to very significantly, dramatically increase their per-capita energy intensity. It is not certain that they will do this in a low-carbon manner – the West must set an example by developing/adopting economic technology capable of producing low-carbon energy on the required scale.

J. Finally, investment in new large generation plant to meet growing demand is at a standstill. In terms of UK gas production, the recent increase in offshore oil and gas taxation was not helpful, being damaging to investor confidence in the sector generally. Regarding generation: there are 13 GW of consented CCGT plant, some of which needs to be built imminently *whatever* options might become feasible for the medium and longer term as a result of policy changes arising from the 2006 review. However, the complete lack of a long-term, equitable and non-technology-specific carbon valuation framework means that even with spark-spreads often now in the required £8 to £10/MWh range, investors are not reaching financial close and starting to build. If new-builds of controllable, bulk generation plant do not commence in 2006, it is quite likely that there will be power cuts of firm demand, going beyond voltage reduction, from 2009. Indeed, the next winters may well be somewhat challenging; we are aware that on 29th December 2005, NGT issued only its second "demand control" warning notice since these notices were initiated with the new Grid Code in 1990, and Monday 13th March 2006 saw the first of the new "gas balancing alerts" combined with a power margin warning. High gas

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[15] "Scientific and Technical Aspects of Climate Change, Including Impacts, and Adaptation and Associated Costs"; DEFRA; September 2004

[16] The government has also just announced (28th March 2006) that the 2010 target of a 20% reduction in CO2 emissions against 1990 levels, will not itself be met.

[17] "Our Energy Challenge"; DTI Energy Review Consultation Document; January 2006

wholesale prices are feeding through to consumers: one domestic gas supplier recently increased its domestic gas supply price by 22% in one leap.

K. To conclude : as a consequence of the factors in all the preceding lettered paragraphs, energy prices in the UK have rocketed to levels that are significantly increasing the number of UK households in fuel poverty[18], and to levels that are putting energy-intensive users out of business – the major Terra Nitrogen fertilising plant in Humberside announced an enduring close-down of all its operations at the beginning of the winter, and some UK plastics, brick-making and other firms later followed suit. Within the EU, industrial electricity prices are currently cheapest in such countries as Finland, France and Belgium[19], which have a certain bias in their national generation mix which makes them less affected by the artificially-engineered oil price linkage in European gas prices. Industrial electricity prices are by contrast dearest in the UK and Germany, whose generation mix differs from that in Finland, France and Belgium in having less nuclear generation.

UK Industry is crippled by a perverse Climate Change Levy that taxes output from low carbon nuclear sources at the same rate as carbon-intensive coal- and gas-fired generation – this is coupled with an absence of equivalent taxation on electricity and gas use in the domestic sector.

Having set out why we agree with the government that there is a problem that necessitated the 2006 review, the Fuellers now suggest solutions or at least directions for possible consideration.

[18] The FUEL POVERTY ADVISORY GROUP (for England)'s Fourth Annual Report states that the number of vulnerable households in fuel poverty in England is now expected to rise by as much as 1 million, and hence to double, between 2003 and 2006, as domestic energy prices are expected to be about 35% higher in real terms than they were in 2003. This is clearly of huge concern.

[19] UK 6.5 p/kWh; Italy 5.5 p/kWh; Germany 5.3 p/kWh; NL 5 p/kWh; Spain 4.8 p/kWh; Belgium 4.7 p/kWh; France 4.1 p/kWh; Finland 4 p/kWh. – source EIUG as presented on chart to CBI/TUC conference 28th February 2006

4. Considerations on New Policy Options

4.1 A Key General Point

Fuellers urge that the government, given the areas of CO_2 emissions growth, should be paying the most attention by quite a long way to **aviation**, then road transport, then other sectors including electricity generation/consumption and the domestic/other use of other fuels. The current policy appears to be the reverse of this.

4.2 Costs of New Generation Options

4.2.1 Cost and Scale of Replacement Nuclear

We have reviewed the available evidence[20] of the cost of new generation options. Nuclear energy does appear to be potentially cost-competitive with other forms of energy; it appears that replacement nuclear can be constructed at a lifetime cost, including decommissioning, of between £20/MWh and £39/MWh. The lower cost, from a Finnish study, is based on a cost of capital of just 5% and relatively low capital cost estimate; the higher cost is from MIT and assumes high capital ("overnight") costs of £1270/kW and a rate of return on capital of 12.6%. There are a number of other international studies showing nuclear costs in between this range, with rates of return and assumed basic capital costs explaining most of the differences between them.

PB Power's March 2006 study for the Royal Academy of Engineering cites £28/MWh for new nuclear costs[21]. With the current special risks carried by nuclear, it would appear that some of the higher figures cited may not be so very far above reality, but we do suggest later in this response how to greatly ameliorate said risks via the policy framework, rendering replacement nuclear plant economic, once these changes to the policy framework are made, against both zero-carbon competitors and even (depending of course on the gas price) new CCGTs.

Lack of advance nuclear design licensing (as is the case now) seriously damages the economics of nuclear replacement-build. Even Sizewell B, the UK's only PWR which was *intended* to be a replica of a proven US design, went through substantial re-design during the licensing stages, due to lack of advance design licensing as a separate matter to the planning process, so that upon completion it was a unique reactor. It is widely-acknowledged that this was almost the sole reason for its cost over-run (its budgeted £35/MWh first-of-a-kind-in-the-UK cost, rocketed to £60/MWh).

Nuclear may have the benefits of economics and scale (compared to renewables), but there are limitations on available sites. These sites are in practice limited to a sub-set of those sites where nuclear generation has taken place in the past. This means that replacement nuclear cannot possibly

[20] Reviewed and compared in "The New Economics of Nuclear Power"; World Nuclear Association; December 2005

[21] www.pbpower.net/inprint/pbpubs/powering_the_nation.pdf

provide the entire solution to our need for low-cost reliable low-carbon, or carbon-free, generation. The debate is essentially only about replacing existing nuclear capacity to retain its general share of the mix; or, allowing all but Sizewell B to close by 2023, so that nuclear from 2023 makes just 2% of our generation mix, and ceases to be by 2035 when Sizewell B closes. We return to this point later; in section 4.13 we discuss what needs to be done to optimise the possibilities at existing or previously-operational nuclear sites.

We note the conclusion of the sustainable development commission (SDC) in its new, March 2006 report plus its accompanying specialist sub-report, that nuclear decommissioning costs (believed to be included in the above range of figures) are known and small for new light water reactors (as opposed to old gas-cooled giants and non-standard prototypes) – they cite a range from OXERA's figure of £250m per PWR to BNFL's more cautious one of £500m. This indicates (as the sustainable development commission acknowledge) that the £72billion UK decommissioning total cost figure for old gas-cooled giants and numerous non-standard research prototypes, is not indicative of future liabilities management figures.

4.2.2 Cost of Near-Zero- CO_2 Coal Plant

The cost of constructing a new PF (basic, pulverised-fuel - the cheapest form) coal plant with carbon-capture-and-sequestration (CCS) is hard to estimate as the technology is some way off the full-scale working prototype level, but according to some estimates would appear to be around £50/MWh. Others suggest data as low as £35/MWh. We very much hope that through the facilitation of R&D and a full-scale whole-cycle working prototype, these costs can be better pinned down. Government support is needed. Fuellers are aware that there are perceived legal barriers to CO_2 sequestration as the relevant international treaties were drafted in the early 1970's before sequestration even existed as a concept; we are very keen to see these barriers clarified and, of course, ideally removed. The risk area of long-term responsibility for waste (CO_2) and liabilities management, and industry funding mechanisms for the same, is just as key to sequestration as it is to replacement-nuclear.

4.2.3 Cost and Scale of Renewables

All-up earnings to renewables are currently about £100/MWh, about half of which is the subsidy element from the renewables obligation and the climate change levy exemption plus perhaps a very little extra from the REGO fuel labelling / marketing value. The implied carbon valuation in these subsidies is £429 per tonne of carbon abated according to Ofgem, compared to €26 / tonne or so (c. £18/Tonne) in the ETS scheme used to value carbon in the market at large. Even at these inflated revenues, the realised supply of renewables projects (and with free transmission and reserve, the costs of which are socialised across all electricity users and not met by the plant developer) has been very limited: current UK wind turbine fleet annual generation is just 1% of the national total. The public have, in spite of the very small scale (energywise) of UK wind developments to date, become quite "sensitised" to the issue particularly in the windiest locations such as Scotland and the Western Uplands, with the recent rejection of a large proposed development at Whinnash, near Kendal. In consequence, developers are now working in areas of somewhat lower wind resource where opposition is not so marked, for example the Fenlands. Offshore developments using proven UK expertise in offshore construction are still more costly; the chart of wind costs spanning several decades in the House of Lords' "Renewables: the practicalities" report (July 14th 2004) indicates that further cost reductions in the capital cost of wind installations generally are unlikely to be substantive or rapid. The cost of new wind plant has been reported since that report as actually *increasing* as more is ordered, rather than decreasing. New offshore wind plant that a few years ago cost £1000/kW, is now said to cost £1600/kW (POWER UK, January 2006), largely due to steel and concrete costs rising – these are energy-intensive to make, a lot of steel and concrete is used per unit-capacity (300 tonnes of concrete, for example, per 1 MW onshore machine which will have an average output of 300 kW – hence, 1 tonne of concrete per kW) - that energy costs somewhat more now than before, in Europe. Large controllable, predictable renewables would be much easier for the grid to accommodate than other uncontrollable, intermittent renewable technologies. However, the lifetime generation cost of the 8 GW Severn Barrage, although apparently well below other renewables options, could reportedly run to £60/MWh[22]; at £12billion capital cost and with a long construction period, it could be hard for the market to finance without state facilitation.

We note that Ofgem in their evidence to the environmental audit select committee in November 2005, stated that new onshore wind developments (capital cost of this plant has been £600/kW in recent years) have transmission costs, socialised across all users and not met by the wind developer, of some £300/kW, another 50% on top of the capital cost of the wind plant. Replacement nuclear developments at existing sites as old nuclear plant closed would not incur these very high transmission works costs, nor would the (again, socialised and met by all users, rather than the project developer) reserve costs associated with wind arise for nuclear.

Ofgem has estimated that the costs of carbon abatement by renewables are very high, with the average to date of abatement from all renewables cited by Ofgem at £429/t/c[23].

Let us now elaborate on reserve and wind intermittency:

In any event, reliance on wind to an extent that is very far into two figures as a percentage would seem to carry significant and possibly irresolvable security of supply difficulties. The Business section of the Independent (p.3) on 31st July 2005 reported that the German grid operator is only prepared to regard

[22] See www.dti.gov.uk/energy/renewables/publications/pdfs/severnbarrage/Severn.pdf

[23] www.dti.gov.uk/energy/consultations/responses_171205.shtml - see 'Ofgem 1', Stephen Smith's letter (with abatement cost estimates on page 3) and document 'Ofgem 2' (further detail on abatement costs on pages 10-11, e.g. average to date = £429/t).

6% of the German wind fleet as “firm” for the purposes of assessment of generation availability at times of peak demand.

OXERA, the energy consultancy, published a report in June 2003 entitled, "The Non-Market Value of Generation Technologies". OXERA reported its forecast that although average wind output is up to 30% of capacity, there will be at least 23 one-hour periods (46 half-hour periods) in a year where the output from all wind turbines in the UK is less than 10% of declared wind capacity, at the same time that demand is 90% or more of annual peak demand (i.e. 23 hours out of that sub-set of demand data where demand is within 10% of max-demand). This is after making allowance for the benefits of wind turbines being distributed around the UK including some modelled off-shore. Across the entire year, OXERA’s model showed that UK wind fleet output would fall below 10% of total “nameplate” capacity of the wind fleet, 18.7% of the time.

Denmark and Germany have seen some very large falls in their national wind generation including the loss of 6 GW of German wind output in one afternoon. This was reported by the German utility eon.netz recently. Denmark and Germany both have the advantage of a large amount of interconnection capacity to their neighbours – proportionately far more than the UK. Let us elaborate a little: recent experience in Germany of the E.ON Netz wind fleet (the largest in Germany with a combined capacity of over 7,000MW) shows[24] that:

Average output during 2004 was around 20% of capacity;

- For half the year the average was less than 14%;
- The baseload capacity avoided by the output from the wind fleet is 8% of rated capacity, and this proportion is decreasing as the amount of wind on the system goes up ;
- If Germany hits its 2020 forecast of 48,000MW wind capacity, this will displace just 2,000 MW of conventional plant.

Professor Michael Laughton, the leading Grid Systems and Control specialist, in his recent “Power in Europe” article proved that the portion of total national wind output that can be regarded as firm is the square root of total national wind capacity (allowing for diversity). Thus, if peak demand were 100 GW (to make the numbers simple), even if wind capacity were 100 GW, for a 20% margin of generation capacity over peak demand, we would *still* require *another* 110 GW of controllable, fossil or light water reactor generation, as just 10 GW of the wind capacity could be regarded as reliable in terms of output at winter peak demand. Hugh Sharman reaches a comparable conclusion in his lead article for the recent Institute of Civil Engineers’ journal in which he argues that 10 GW is the maximum UK wind capacity that the Grid can

[24] “E.ON Netz Wind Report 2005”; E.ON Netz; 2005

accommodate. A correspondent in the March 2006 edition of *IEE Review* reaches an identical conclusion to Laughton but by a different calculation.

We are aware of analysis by Graham Simden[25] showing the marine current output, even from a geographically-diverse range of devices at locations of differing (offset) tide times such as to, in aggregate across this optimally-located fleet, minimise intra-day variations in total fleet output, would *vary by a factor of up to 4 from day to day across a month due to spring/neap tidal differences – the minimum aggregate (fleet) output sometimes coinciding with the time/day of peak demand.* National Wind fleet output has a tendency to minimise at the time of peak demand where cold weather was caused by an anti-cyclone (there is no insulating cloud cover at this time; the average spread of a high pressure weather system in Europe is 1000 km[26]). Therefore it is not the case that variations in marine and wind renewables fleet outputs can be counted upon to always "net off one another", as is sometimes suggested by renewables lobbyists. However, at least the varying output of marine current turbines would be predictable well in advance, and we very much hope that marine current turbines can usefully contribute towards the achievement of reduced UK carbon intensity.

These issues with security of supply of renewables would seem to place a cap on the amount of capacity that can ultimately be accommodated in the UK without incurring excessive reserve costs.

However, growth in renewables' output can feasibly make a significant contribution to meeting some of the *growth* in UK electricity demand – the government has an aspiration that renewables output should grow as a percentage of UK generation by about 1% a year. If electricity demand growth slows down from its steady 1.5% a year in recent decades, for example if the growth rate could be cut radically by 1/3rd to 1.0%, which could occur if new and very successful energy efficiency measures were identified and adopted by the population at large (and if, and only if, large numbers of new homes were **not** built), then the growth in renewable generation may, if it reaches the target, be able to just cover this growth in demand for a time. What the growth in renewable generation cannot possibly do AS WELL as this, is replace the output from our declining nuclear fleet – the default position is that this is replaced by CCGTs producing CO_2 by burning imported gas; gas which over the decades will certainly become more expensive, and for which the nation has only very limited storage capacity. What the growth in renewable generation also cannot possibly do, then, is to go further still, and allow a generation sectoral reduction in CO_2 emissions of 60% by 2050, let alone go further still and offset the burgeoning disaster that is road and air transport. Yet somehow, we must achieve all of this. CCGT carbon-intensity is normally understated as the considerable amount of energy involved in chilling, liquefying transporting and the regasification and compression of natural gas that is transported as LNG, is easily overlooked, as is the global warming potential of the 9% methane leakages (emissions) along prolonged

[25] www.eci.ox.ac.uk/pdfdownload/energy/wavetidalpresentation.pdf - See for example the graph on the right page 11
[26] University of Kassel study, cited in article by AMEC wind in the UK's *ReNew* magazine, Feb 2004

Russian gas pipelines to the West. World gas systems generally have methane leakage of 4%.[27]

The one rider or qualifying statement, in stating that renewables have limited ultimate potential, is that this would be less so if the Severn Barrage were to be built (with built-in pumped storage), providing 8 GW of reliable, semi-base-load, controllable generation. At £60/MWh, this would not be cheap and being an exceptionally-large project with an exceptionally-long construction period, could be hard to privately-finance without government facilitation. However, given the ultimate limitations on nuclear sites that are both available and suitable, it may be needed - alongside carbon sequestration of the output from modern coal plant.

4.2.4 Cost of electricity from new gas-fired generation projects; and, the price of retail gas

New CCGTs might come in at around (conservatively and with a very wide margin of error) £54/MWh. This estimate can be arrived at from a basic capital cost element of £8/MWh together with the gas cost, expressed in p/therm, divided by about 1.43 to "net back" to an electricity generation cost. In this example, the gas cost used (hard to assess in an unstable market) is 55 pence per therm, representing recent levels before the gas storage facility at Rough failed. This gives a basic cost of £46.50/MWh, to which a carbon emissions cost of say £8/MWh (arising from the effect of the emissions trading scheme[28] at about €26/tonne of carbon) must be added. Hence £54/MWh. It is thought impossible to buy bulk gas forward by more than a year or two at present, so even moderately robust say 15-year project costs cannot be estimated.

The high price of gas has also caused retail prices to rise radically to both domestic and industrial customers. Many industrial consumers in the UK have been forced to shut down their manufacturing operations in fertiliser, bricks, plastics and ceramics manufacturing, among others.

It has been said by some that very long-term off-takes between UK large consumers and putative new large generation plant may not be permitted. This is concerning as these contracts would in no way be anti competitive, provided all consumers in the sector have access to such contracts if they are interested. The possibility of such contracts may be very useful to facilitate replacement plant being built, and must be allowed for with a clarifying statement from the authorities.

The Fuel Poverty Action Group (for England)'s Fourth Annual Report states that the number of vulnerable households in fuel poverty in England is now expected to rise by as much as 1 million, and hence to double, between 2003 and 2006, as domestic energy prices are expected to be about 35% higher in

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[27] Video presentation made to TOPNUX conference 22nd March 2006 by Professor James Lovelock - available as streaming video on BNFL website.

[28] As applied to CCGT site-only carbon emissions, ignoring both the LNG process and the CO2-equivalence of methane-leakage

real terms than they were in 2003. This, as the Group says, is clearly of huge concern.

UK Industry is further crippled by a perverse Climate Change Levy that taxes output from low carbon nuclear sources at the same rate as carbon-intensive coal- and gas-fired generation – this is coupled with an absence of equivalent taxation on electricity and gas use in the domestic sector. Fuellers call for the abolition of the Climate Change Levy. If this is not achievable, we ask instead that the same *exemption* from the Climate Change Levy that is given to certified consumers of carbon-emitting CHP plant, should be given to certified consumers of virtually-non-carbon-emitting nuclear plant.

4.3 Energy Efficiency and the Demand Side

On demand side, we support a balanced approach to energy savings, which looks at the true costs and true overall benefits of different options. Large-scale behavioural changes are VERY difficult to achieve without legislation or energy price pressure (although recent price increases will help make measures more cost-effective).

Specific policy/regulatory measures which could be helpful might include:

- Legislation to reduce energy wastage (more efficient appliances, including self-switch-off appliances to reduce “standby” losses)

- Incentives for “smart metering” – so householders and businesses can see the real-time costs of their energy usage

- Decent rules, with teeth that are properly enforced, to ensure that new housing and new commercial developments are built to the very highest energy efficiency standards.

- Legislation with teeth so far as practicable forbidding the routine leaving-on of all lights in empty retail and commercial premises, other than when actually being cleaned. We note that the M1 motorway, for example, has lights on the first 100 miles of it North of London, and not thereafter – are they in fact necessary, as there is presumably nothing unique about the part that is near to London?

- Investment in R&D for development of more energy efficient technologies including in transport, which is a very fast-growing contributor, already accounting for around one quarter of total UK CO_2 emissions.

- There should be sustained communications to inform the public why prices will inevitably be rising over coming years, as we import more energy and pay a premium for reducing carbon emissions. This message should be coupled with education on ways to save energy, and on which are the low-carbon power generation technologies. Fitting all primary schools with small wind turbines (a current policy goal) if not mentioning the pro's and con's of wind against other low-carbon power generation technologies (costs, scale, intermittency), does *not* comprise a balanced, scientific, unbiased education; it would represent a shallow, not a holistic, education.

- The domestic burning of logs for heat can be beneficial – the growing plant absorbed CO_2, and logs if left to decay emit methane, a very potent greenhouse gas (21 times worse than CO_2); these domestic fires can also displace the householders' consumption of methane (and some electricity usage) via his central heating or via his "economy seven" storage radiators (or oil/propane consumption) in no-mains-gas areas, and so reduce our national dilemma.

- New building codes for gas distribution should use material that is suitable for conveyance and control of hithane (a mix of methane and hydrogen that could be used on the gas grid; we come to this later) and hydrogen.

- Measures that restore financial and legal privileges to the institution of marriage, and other measures which may help stabilise or reduce the UK's population and thus prevent the predicted 5 million increase in the number of homes in England alone by 2026, from coming to pass.

- If new homes are built in numbers : energy-efficient coastal desalination plant that makes use the waste heat from relevant large generation plant – given the current use of coastal sites, this would be nuclear plant.

4.4 A Balanced Generation Mix

Whatever the relative considerations of economics and scale, as discussed above, limitations on available sites mean replacement nuclear cannot possibly provide the entire solution to our need for low-cost reliable low-carbon, or carbon-free, generation ; we confidently believe the solution will be found in a diverse and well-balanced mix with adequate proportions of coal, renewables and nuclear within it, subject to some ultimate practical (for renewables, these are both economic and physical) constraints. It is evident to us that R&D will be important to better discover and scope some of these possibilities – see later.

4.5 Carbon Intensity of the Options

4.5.1 Gas-Fired Generation

Full-life-cycle (or "cradle to grave") carbon intensity of generation is of immense importance to the avoidance of climate change.

New CCGTs have direct (at-the-power-station) emissions of CO_2 of 360g CO_2/kWh at the power station[29], but if fuelled by North Sea gas their "full lifecycle" emissions are said to be 440 g/kWh; if fuelled, as they will be in the future, by very-energy-intensive LNG the "full lifecycle" emissions are 660 g CO_2/kWh (Friends of the Earth figure based on LNG from Qatar[30]).

If fuelled by methane-leaking Russian pipelines, as they will be to a fair degree (alongside the LNG) in the decades to come, the "full lifecycle" *equivalent* CO_2 emissions are 695 g CO_2/kWh (Friends of the Earth figure – same reference as for LNG, see above). The Russian gas system leaks 35 million metric tons of methane annually, implying leakage of 9% of throughput[31].

Gas systems generally leak about 4% of the methane transmitted, and this is said to be virtually unavoidable[32]. Methane has a very high greenhouse gas potency – it is 21 times that of CO_2.

In other words, the lifecycle greenhouse gas emissions associated with using imported gas from Qatar or Russia in a UK CCGT are 50% higher than those from simply burning gas from the North Sea.

The ETS (emissions trading scheme) scheme does not allocate full lifecycle equivalent carbon emissions and therefore gives particularly low emissions formally to CCGTs – much too low; a point made recently by environmentalist Professor James Lovelock (see the preceding, last footnote reference which is referred to above). In addition, the ETS Phase I as implemented in the UK gives **free allowances to new CCGTs** so that they do not even faces the costs of their CO_2 emissions, and don't have to pay for the emissions rights in the market – this is quite wrong and rides a coach and horses through any idea of equitable carbon pricing. These mistakes must not be replicated in ETS Phase II.

4.5.2 Coal

Conventional pulverised-fuel coal plant has emissions of 955 g/kWh of CO_2. With "carbon capture" plant, up to 85% of CO_2 can be captured and sequestred for very long periods of time. CO_2 can be captured from the flue gases at supercritical pulverised fuel plant, or at the pre-combustion stage at IGCC plants. The captured CO_2 would be stored underground in either exhausting or exhausted oil and gas fields, or in deep saline aquifers. IGCC plants are less well-proven than pulverised-fuel plants, but offer the additional advantage that removal of the CO_2 at the pre-combustion stage provides a stream of hydrogen; this could be mixed onto the UK natural gas distribution grid (NTS) to substitute for some of the (imported) methane.

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[29] e.g. see recent sustainable development commission report, March 2006 – NB: multiply carbon figure by 11/3 to convert to a CO_2 figure

[30] See note 1 of www.foe.org.uk/cymru/english/press_releases/2004/anglesey_gas_plant.html

[31] www.crest.org/repp_pubs/pdf/issuebr8.pdf - page 14, and footnote 33

[32] Video presentation made to *TOPNUX* conference 22nd March 2006 by the leading environmentalist, Professor James Lovelock.

Cleaner coal plant using supercritical boilers and/or fluidised-bed technology may bring CO_2 emissions down to 700 g CO_2/kWh or perhaps even lower (if used without sequestration).

Coal plant emits sulphates to the atmosphere – from sulphur that was originally in the coal. This has recently been found to be beneficial, to general surprise. The UK Met Office and other climate change specialists say this is likely to be very helpful in reducing global warming due to the new science of the "sulphur cycle". Sulphates in the upper atmosphere – generated by industrial activities including coal-fired power stations, and by some modes of transport[33] – reflect sunlight back into space, thereby offsetting the effects of global warming by reducing the level of sunlight reaching the earth's surface (the 'global dimming' phenomenon).

The Met Office has wanted to model the sulphur cycle, but until recently it did not have the computer time to do so, as this is particularly resource-intensive to model. By using spare clock cycles from people's home computers (volunteered by the owners), the met office has recently finally been able to model the sulphur cycle.

However, "flue gas desulphurisation" (FGD) plant, formerly fitted to only one UK generator, is now necessary at all coal stations if they are to continue in operation once the EU's "Large Combustion Plant Directive" (LCPD) comes into force in just a very few years. The FGD plant reduces the amount of sulphates emitted to the atmosphere and so reduces the beneficial effects of the sulphur cycle.

The LCPD was produced prior to the realisation of beneficial effects of sulphurous emissions in alleviating global warming. Due to the energy used in grinding up the limestone used in this process (which is quarried elsewhere, but prepared on site), the FGD process where fitted will, by using 30 MW of power per 500 MW coal set to which it is fitted, reduce absolute thermal efficiency by about 2 per cent, and hence reduce relative thermal efficiency by 6 per cent – thus, increasing CO2 emissions per kWh by 6%. Hence, the fitment of FGD enhances (makes-worse) global warming twice over – once by causing the emission of six per cent more CO2 per unit energy generated, and then a second time by reducing the beneficial effect of sulphates in the atmosphere.

4.5.3 Nuclear and Renewable Generation – effectively zero by comparison to fossil plant

Nuclear power comes in at around 16 g/CO_2 per kWh, based on the sustainable development commission's (SDC) March 2006 main report[34] on nuclear power (para 2.1.1). SDC have also just released a subsidiary special report on this topic, in which SDC comments that nuclear and wind power

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[33] Road petrol now has sulphur content in many cases of just 10 parts-per-million, whilst marine "bunker" fuel can be supplied at up to 4% sulphur, as the use of marine "bunker" fuel is not regulated in this respect.

[34] www.sd-commission.org.uk/publications/downloads/SDC-NuclearPosition-2006.pdf

have the same CO_2 emissions; they include a table featuring 21 separate international studies which are broadly compatible in their results. All the results in the SDC's table are two orders of magnitude below the emissions from fossil-fired plant in the absence of carbon sequestration. Some variability in the results does arise from the difference in energy-efficiency between centrifugal and gas-diffusion approaches to uranium enrichment. France in particular has been greatly handicapped for many years by her inability to master the centrifugal technology, meaning that she has been reliant on gas-diffusion plant using 30 times as much energy as a centrifuge – some 3000 MW when her gas-diffusion plant is operating at full capacity. However, last year she has finally been able to purchase centrifugal technology under licence from the United Kingdom's *Urenco.*

The EU's "ExternE" review[35] also shows full costs of a wide range of externalities from nuclear energy are low and similar to renewables.

4.6 Resource Adequacy and Sustainability

One needs to consider whether each fuel source suffers from the same problems as does gas – is it sourced mainly from unreliable and unstable regimes; is its price stable; how easy is it to stock sufficient quantities to cover many months use?

In the short term, reliable gas imports can be sourced from countries such as Norway. In the longer term, however, as demand is forecast to grow across Western Europe, supplies are likely to come from countries further afield that hold the largest reserves. The bulk of the world's gas reserves are in Russia (as can be seen in the chart), with other significant supplies in countries such as Iran, Algeria, Saudi Arabia and Qatar. Although there is expected to be a substantial amount of gas imported as LNG (even though the total CO2 emissions from this form of gas are high) it is anticipated that much of the gas from these countries would still have to be exported to Western Europe by means of long pipelines, passing through many countries along the way. This would require major infrastructure development in Europe, including terminals in the UK, and increase the risks of potential interruption to supply.

Those strongly opposed to nuclear power will raise the source-resource issue as a matter of uranium resource adequacy. All professional sources of information dismiss the uranium resource adequacy concerns. We find the March 2006 Sustainable Development Commission (SDC) report[36] (chaired by Jonathan Porritt, a former director of Friends of the Earth) useful on this topic. They issue a detailed supporting paper, but the key quote from their main report is probably sufficient here:

[35] www.externe.info
[36] www.sd-commission.org.uk/publications/downloads/SDC-NuclearPosition-2006.pdf

"…. our evidence also suggests that on current predictions, there are no major concerns over the long-term availability of uranium. A manageable increase in price would stimulate a significant increase in economically viable reserves, without allowing for further exploration. Our evidence also points out that in the past uranium reserves have been consistently underestimated, and that as a resource it has had far less prospecting than other minerals. This would suggest there is probably enough uranium at a reasonable price to match future demand, and that as uranium represents a very small part of the overall cost of nuclear power, the impact of future price rises will be limited."

One might add that, if at some stage uranium did become more costly, this would merely render fast breeder reactors (FBRs), which obtain 100 times as much energy per unit uranium, economic once again – Russia, which has had a reliable FBR at Beloyarsk since 1983[37], is now finishing the construction of the Beloyarsk-4 BN-800 fast reactor for operation from 2010. The world's first molten-lead-cooled fast breeder is also to be built there – it is to be known as BREST with full commercial operation from 2020. Russia's earlier FBR, "BN-350", provided both electricity and desalinated water for Aktau city and neighbouring industries for 26 years before being shut down only in 1999 – a truly reliable and sizeable Fast Breeder reactor. FBRs are not hard to build, the world's first power-generating reactor, EBR-I (Experimental Breeder Reactor-I), was an FBR. They merely have slightly higher capital costs and are therefore only economic if uranium is in shorter supply, which is why FBR designs are viewed as leading "Gen IV" options.

Fuellers have recently had a talk from an expert from the JET-Culham international fusion research project, and key Fuellers have also recently visited the JET Culham site; more plan to do so. We see excellent longer-term promise from nuclear fusion, within the next 50 to 100 years. From this point, the use of heavy water, with virtually unlimited supplies, will progressively replace the use of uranium once fusion reactors, initially costly, become more economic (this may be partly dependent on uranium becoming more expensive).

Fusion can also be used to transmute nuclear waste from fission reactors - the waste is placed in a cell where it will receive high energy neutrons from the fusion reaction, generating extra power as a bonus. The neutrons inside a fast breeder are not fast enough to efficiently transmute all the waste within the fuel, as they only have c. 100 kEv energy. The neutrons inside a fusion reactor *are* fast enough to efficiently transmute all the waste, as they have c.14.5 MEv energy. Thus, we can see a way to get the best from fission and fusion working in harmony, in a manner that destroys the nuclear waste in the spent fuel from a fission reactor.

4.7 Stocking Considerations are Key for Security of Supply

The Fuellers would comment that coal has the capability to be readily stocked, albeit it takes up 30 million times as much space (and 3 million times

[37] http://www.industcards.com/nuclear-ru.htm and http://www.uic.com.au/nip62.htm - see Beloyarsk-3

as much weight) per unit energy content as uranium. Coal comes (just like uranium) from a wide range of stable regimes at prices that have been relatively stable over long periods of time, at least compared to the price of gas. Uranium, comprising a small fraction of reactor generation costs, is considerably cheaper today than it was in 1976, and is readily forward-hedgeable over many years in liquid commercial markets.

Both coal and uranium are more stable and abundant resources than natural gas.

Coal-fired generation remains very important to the UK: its capacity met 50% of UK instantaneous electricity demand at peaks (during the winter of 2005/2006.

We believe that all new CCGTs should, as a condition of their planning consent, have generous (many days) on-site stocking of liquid fuels and the ability to burn them must be maintained by the CCGT operator.

The UK would appear to need strategic gas storage and cannot be 80% reliant on one gas storage facility, with national gas storage capability far below other European nations. Fuellers note the recent Ilex report for UKOOA[38].This explains the "storage paradox": storage is only really valuable and worth investing in when gas prices – spot and forward - are very high, but these high prices make the cost of cushion gas ruinous. When cushion gas costs are low storage is less valuable.

The result of this paradox is that "strategic" gas storage investments are very difficult for investors to justify in a competitive market. Ilex suggest that due to the increase in UK reliance on imported gas, a case can be made for more strategic gas storage in the national interest in order to ensure security of supply – e.g. in the event that the Langeled or IUK lines go down. However, the market is unlikely to justify the "insurance premium" for such a remote possibility. Ilex therefore suggests that the alternative would be for the government to impose the cost of strategic storage on the industry and that this option should be considered as part of the forthcoming energy review. There seems some merit in this idea; perhaps some form of storage obligation could be justified. Certainly, continental governments do not appear to leave the matter of gas storage entirely to the market (see paragraph E of section 3).

4.8 Fuel Substitutions

Coal bulk gasification could potentially produce "syngas" as a dedicated replacement for methane in CCGTs, at a price of 70 pence a therm, capping the ultimate price of gas for power generation (the syngas could never be put out on the gas grid to homes). Coal bulk gasification could take place underground in sub-sea and other seams that, although thick, cannot be economically physically extracted as solids (mined). There are quite serious

[38] www.oilandgas.org.uk/issues/gas/ilexreport2005.pdf

CO_2 implications from this technique, but the CO_2 could be sequestred. We wish to see more research funds devoted to sequestration and gasification technologies; the existing NFPA surplus fund would be very suitable towards this end and legal means of its release should be clarified as a result of the new review.

Note: syngas substitute as derived from coal is both lower in energy than methane and rich in carbon monoxide and so could only be used in dedicated facilities such as CCGTs – it could not be mixed onto the NTS gas grid for use in domestic appliances, whereas some commentators have suggested that hydrogen could be safely so mixed.

New building codes for gas distribution should use therefore material that is suitable for conveyance and control of hithane and hydrogen.

We believe that all new CCGTs should, as a condition of their planning consent, have generous on-site stocking of liquid fuels and the ability to burn them must be maintained by the CCGT operator.

Burning logs at home can be beneficial, as previously noted: if logs are simply left to decay or placed as domestic refuse (as is so often the case with domestic tree surgery work) they emit methane, a very potent greenhouse gas which is 21 times worse than CO_2.

4.9 Vulnerability of Energy Facilities to Terrorism

4.9.1 History

We provide in Appendix 2, a summary of past terrorist attacks on energy facilities in the United Kingdom.

The responsible body, the Provisional IRA, decommissioned its arms in July-September 2005. Among the terrorist weaponry formally listed as destroyed were:

> *7 surface-to-air missiles (unused); 3 tonnes of semtex; 20 rocket-propelled-grenades (RPGs); 30 heavy machine guns; 7 military flame throwers - as well as a somewhat larger numbers of rifles, handguns and grenades*.

This does indicate that they had secured access to weaponry that went well beyond small arms. However, some of these items / categories had not been used – there may have been a lack of familiarity with their actual use.

4.9.2 The Present

The IRA is now on enduring cease-fire. Selected other firms large and small are having to face the serious threat of violence including incendiary devices etc., that anyone even distantly linked with the UK’s leading medical research community does. This latter risk does not affect the energy sector, but the risks now are perhaps worse than the IRA or even animal "rights" terrorists: there is a quite unapologetic and deliberate attempt to murder large numbers of people, rather than merely facilities.

Religion is now the key source of terrorism which UK planners and operators of industrial facilities generally now consider, with Europe now in some cultural tension. We would stress that (as with industrial facilities in other sectors including water supplies/reservoirs, manufacturing plant, city finance) the terrorist risk cannot be totally eliminated, as the authorities have themselves repeatedly emphasised, and must therefore be managed and mitigated with proportionate but effective measures that do not prevent our business from going on. The energy sector at least does not face the threat of violence including incendiary devices etc, that the UK's leading medical research community, and associated firms both large and small, face.

We now consider in turn those elements of our sector where there has been the most public debate or concern; we have tried to source independent analysis from outside those directly involved in the particular sector where possible, whilst avoiding citing environmental movements or local oppositionists whose viewpoint may not be well-balanced:

4.9.3 Nuclear Power Stations

In the nuclear domain, the Sustainable Development Commission has just completed an investigation of vulnerability. The chairman of SDC is Jonathan Porritt, a former director of Friends of the Earth who may be regarded as particularly independent of the nuclear industry. In its March 2006 report SDC says:

"The possibility of a terrorist strike on a nuclear plant has been a focal point for security analysts since 9/11. Modern reactor designs have substantial containment buildings which are unlikely to be breached even by a crashing commercial airliner, and the reactor fuel is protected against impact and fire by other structures. The industry assessment is that attempts at damaging the plant, either by external attack or sabotage, will probably cause the reactor to shut down safely once a fault is detected."

We agree, and do not believe that nuclear facilities are uniquely or indeed particularly vulnerable to terrorism, and nor do we believe that is so of other energy facilities.

4.9.4 Liquefied Natural Gas (LNG)

The chairman of Lloyds, Lord Levene, spoke on "LNG and terrorism" in his speech to the Houston Forum on 20th September 2004[39]. Lord Levene said that Gas carriers, whether at sea or in ports, make obvious targets, going on

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39 www.lloyds.com/News_Centre/Briefings_and_speeches/Can_the_21st_century_corporation_remain_secure_Lord_Levene_Chairman.htm

to make a statement that compared the energy content of an LNG tanker with "the force of a small nuclear explosion".
Lord Levene was perhaps influenced at the time of this talk, by the cost to the insurance market of a recent accident which has no relevance in the UK: the simultaneous explosions and later fires[40] at two recently-refurbished liquefaction trains in Skikda, Algeria in January, 2004 realised an insurance claim of $470 million according to the insurance brokers, Willis[41]. The UK has no LNG liquefaction trains and avoidable mistakes had been made in operating the plant at Skikda.

We believe the "nuclear explosion" part of Lord Levene's statement in relation to LNG shipping, to have been open to being misunderstood. Although our former Lord Mayor was referring to the energy-equivalence, a reader of his statement may think he was suggesting that an LNG tanker could itself become a bomb. An LNG tanker's contents are not flammable *within* the vessel – they are only flammable when admixed with oxygen in the air following a release. There is a physical limit of the rate at which the liquid LNG could emerge from a damaged vessel, no matter what the (unlikely) incident, and therefore a comparison with the energy content of a bomb, which releases its energy almost instantaneously, has the potential to be misunderstood.

We have no particular expertise in the effects of an explosion alongside an LNG tanker, all of which are double-hulled; such an attack has never taken place. A comparison is possible: on October 6, 2002, a small terrorist boat exploded adjacent to a double-hulled French oil tanker the *Limburg,* causing a fire and spilling her oil. The hole in the Limburg's outer hull is reported as having been 8 metres in diameter[42], but the hole in her inner hull was not as large. The explosion alongside the warship the *USS Cole*, arising from the same mode of attack, although initiated at the water-line, did not make a large enough hole to sink her.

Even upon escape to the sea surface, which would be at a limited rate, the initial vapour cloud from the boiling LNG would only burn on the *surface* of the cloud or plume. There may be a small cloud of aerosol methane-air mix arising instantaneously from the initial incident, but it should not be large. Some more intimate mixing with air may be possible if there is considerable drift of the plume away from the point of release before it reaches a source of ignition, but this is unlikely: the minimum ignition energy of LNG vapours is just 0.29 mJ (milli-joules), whereas static electric discharges due to walking on a carpet or brushing human hair average 10 mJ, or 35 times the amount needed to ignite LNG vapours[43]. The plume of low-level vapours would therefore be unlikely to drift long distances before its surface layer reached a source of ignition, and - failing this - upon mixing more intimately with air, the

[40] www.energy.ca.gov/lng/news_items/2004-01_algeria_factsheet.html - "a steam boiler that was part of an LNG production plant exploded, triggering a second, more massive LNG vapor-cloud explosion and a fire that took eight hours to extinguish"
[41] www.willis.com/news/publications/Energy_Market_Review_2004.pdf
[42] http://archives1.iomosaic.com/whitepapers/Managing%20LNG%20Risks.pdf fact number 5
[43] http://archives1.iomosaic.com/whitepapers/Managing%20LNG%20Risks.pdf – fact number 3

methane vapours (initially drifting at low level) would gain heat to the point of methane's neutral buoyancy in ambient air, minus 110 degrees centigrade, and rise harmlessly away from that point.

Although LNG vapour expands 620-fold once outside its usual containment, the rate at which it is able to do so is limited. The volumes of methane generated per square metre of land are very low, as the land is itself rapidly cooled and unable to rapidly supply the vaporisation heat. On sea with the air above at ambient temperature (i.e. assuming the LNG "pool" gains heat only from the sea), the rate is faster (the cooler sea water continually drops away beneath the LNG) and more constant, but is still limited to 15 cubic metres per square metre per minute[44]. Any explosion based on expansion alone ("rapid phase transition") would be extremely minor. For a spill covering a sea surface area of, say, radius 25 metres, the methane boil-off volume/rate at ambient temperature is limited to 29,000 cubic metres per minute, *if* the LNG can exit the vessel fast enough – which is unlikely as a catastrophic breach should be impossible given the stringent LNG tanker construction standards (and, going beyond design theory, this is further validated with a view to the *Limburg* and the *USS Cole* practical analogies). If a tanker holds say 138,000 cubic metres, this means boil-off to atmosphere of the methane in this instance would take nearly 5 minutes.

Professor James A. Fay of Massachusetts Institute of Technology has made a report for the Boston, USA authorities "Spills and Fires from LNG Tankers in Fall River" was published on August 26th, 2003. He found that from an attack on an LNG tanker, the radiant heat would be fatal to humans in the *worst case* at distances up to 0.68 mile. In fact, regulations mean that there will <u>not</u> be habitations at this range, and in a serious incident, precautionary evacuations would take place over a larger area. (US regulator FERC have analysed the impacts of tanker failure[45] and determined appropriate flammable vapour and thermal exclusion zones; the outcome of this work has been broadly adopted in other countries).

Janes, the leading world defence and terrorism publisher has published on this topic. Its article "Liquid Gas: the Next Terrorist Target?" in the July 2004 issue of Jane's Terrorism & Security Monitor by Dr JCK Daly[46] tells us about Richard Clarke, the American government's former top counterterrorism official. In his book *Against All Enemies*, Clarke reportedly states that *al-Qaeda* used LNG tankers to smuggle its agents into Boston, USA from Algeria. This clearly indicates that LNG tankers were *not* seen as a viable or attractive target by those terrorists, notwithstanding the portrayal of an attack using what the dialogue tells us is a "shaped charge" device in the somewhat propagandist new George Clooney film, "*Syriana*". We discount this film as unrealistic.

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[44] Source : Inst Gas Engineers and Managers March 2006 LNG safety meeting at Energy Institute
[45] see for example Consequence Assessment Methods for Incidents Involving Releases from LNG Carriers- http://www.ferc.gov/industries/lng/safety/reports/cons-model.pdf
[46] www.janes.com - free registration required

Moving away from terrorism, LNG vessels, like oil tankers, are crewed to the highest standards, and regularly inspected requiring stringent safety certificates prior to being admitted entry to an LNG port. There has never been an accident that has resulted in a loss of cargo containment in 44,000 loaded ship voyages; there has just been one low-speed grounding off Gibraltar.

There is one rather well-known case history of an oil tanker losing all her cargo on entrance to Milford Haven - the *Sea Empress* incident in 1994. A full investigation took place to make sure that the incident could never again be repeated. The vessel was under pilotage by a professional pilot supplied by the local port authority. The accident was found by the subsequent enquiry to be due to a misunderstanding of the tides under certain conditions that was shared by all the authority's pilots, and which of course has since been thoroughly corrected through proper training. Advanced computer simulators are used by the Port Authority to train its control room and other staff, as has been seen at first hand by the Fuellers in their 2005 fact-finding visit to Milford Haven.

4.9.4 Other gas and oil facilities including terminals at sea

The IRA's UK bomb attacks which were "successful" to varying degrees have included an oil terminal in the Shetland Islands, a gas works in Warrington, England, and an oil terminal in North Shields, England. Its attack on Belfast Gas Works was unsuccessful due to premature detonation.

In Indonesia, Exxon-Mobil's Arun gas processing terminal was forced to shut down for 5 months in 2004 after an attack by separatist rebels. That cost the Jakarta government 100 million dollars a month in lost revenue, according to Lloyds of London.

The 16th February 2006 *accidental* explosion at Rough gas storage terminal[47] has resulted in damage that will, according to Centrica's "Force Majeure" public bulletin of 24th March[48], take until October 2006 to fully repair for gas withdrawals, due to the need to replace or bypass 30 kilometres of cabling. However, a successful terrorist attack on a UK offshore facility or onshore terminal is thought most unlikely as suitable planning measures are believed to be in place in the UK sector, great attention being given to dealing with all conceivable threats, both natural and man-made.

4.9.5 Electricity Infrastructure

On 22nd March 2006 press reports stated that a radical islamicist named Waheed Mahmood had infiltrated the national grid with a view to attacking their power facilities; he and 6 other radical islamicists are under trial and evidence includes their alleged procurement of half a tonne of ammonium nitrate and powdered aluminium, both possible components of explosives

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[47] A mobile glycol tank caught fire on 3B platform

[48] Available by clicking from : https://storit.centrica-sl.co.uk/storit/p_cust_menu.draw_screen?in_session_id=46860474A4E4E4A4E0311130F6BBF5C

The only Crown Court conviction of IRA terrorists for real or planned attacks on electricity facilities was in 1995 and was in relation to planned attacks on National Grid's transformer substations around a major UK city. However, much of the key electricity supplies there are located underground and would therefore is safe from attack.

There has been no successful attack on electricity infrastructure on mainland Britain, although cabling from Ulster to Eire was attacked in the past.

4.9.6 Conclusion on Terrorism

We strongly welcome the decision to ask HSE to review safety issues of all leading power generation technologies, including LNG and gas storage, nuclear, carbon capture and storage, hydrogen, transmission and renewables. The HSE study will ensure that an objective and consistent approach is brought to this important area[49]. **We welcome and agree with the HSE's statement that: "There are risks associated with energy generation and distribution, as with most industrial activity. Sensible health and safety is about managing such risks effectively, not eliminating them, and ensuring the regulatory system enjoys public confidence".**

4.9.7 International Security: Proliferation

Having addressed terrorism for energy facilities, we now consider another argument frequently raised around nuclear power: Proliferation of nuclear weapons and the risk of their acquisition by rogue states is a concern raised from time to time. The SDC argues that "If nuclear power is part of the UK's chosen solution to climate change, then it would be considered a suitable solution for all countries", and clearly has some concerns here. These are hard to understand. A uranium-based atom bomb as used on Hiroshima, notwithstanding its maximum yield of 20 kT or so, is still perfectly potent, and does not require reactor technology or that a wide range of obstacles be overcome – it merely requires enrichment technology (which Iran already has), and a very simple device akin to a cannon with a sealed muzzle, to set it off.

By contrast a plutonium-based bomb requires access to a far greater range of very hard-to-come-by items, including ALL of the bulleted items below:

- a short-fuel-cycle graphite-moderated (or heavy-water-moderated i.e. CANDU – this is said to be how India got her nuclear weapon) reactor plus plant for processing of spent fuel (or other supplies of concentrated Pu-239)

- Supplies of Lithium-6 and a particle accelerator to convert it to Tritium; or a direct source military Tritium (in critically short worldwide supply due to its half-life being 10 years)

[49] http://www.hse.gov.uk/press/2006/e06005.htm

- (even more critically) special explosive lenses now manufactured only at a single site in each of France, Russia and the USA (but no longer in the UK)

- Supplies of heavy hydrogen (deuterium).

Replacement light water-moderated reactors would not even be suitable for the production of military plutonium as their spent fuel has too high a proportion of (non-fissile) plutonium-240 in it in relation to (fissile) plutonium-239. Such constructions would not be relevant to the proliferation debate, and would be replacing Magnox reactors which in a few cases were capable of being operated to produce military plutonium (albeit they were not so operated for many decades or, in most cases, ever). "Military" plutonium must have isotope 239 at a concentration of 93% or better, and plutonium cannot be concentrated or enriched as between these two isotopes, 239 and 240. In any event, just to repeat and emphasise our point – a uranium bomb is a perfectly "adequate" nuclear weapon for a rogue state to possess, and does not have any of the numerous extremely difficult hurdles in its construction that a plutonium device has; the only significantly-difficult element is the requirement for uranium enrichment apparatus, such as a centrifuge.

In fact, nuclear fission is currently playing a major role in deproliferation. A range of reactors are being used to burn up existing international stocks of fissile (239, military) plutonium when mixed with uranium as "MOX" (mixed-oxides of plutonium and uranium) fuel. Stocks of highly-enriched (weapons-grade) uranium are also being burnt up in civilian reactors, displacing the need for mined uranium ore. The best-known programme, among many of them, is the annual sale by Russia of 30 tonnes of her 500 tonne stockpile of highly-enriched (weapons-grade) uranium – the sale lasts until 2013 and is supplanting 13% of world uranium mining needs. This programme is called "Megatonnes to Megawatts".

The murder of Sergei Bugayenko, head of the International Centre for Nuclear Security, is however disturbing - the centre was created as part of a deal reached with America to ensure security at sometimes-vulnerable Russian nuclear sites. Russia's weapons stock is viewed by some as susceptible to theft for re-sale in the corrupt post-Soviet era.

4.10 Waste - Nuclear Waste, and Sequestered CO_2 Waste

The Fuellers looked back to one of the cornerstones of the debate about nuclear waste, the original 1976 RCEP (Royal Commission on Environmental Pollution) committee's recommendation:

"*There should be no commitment to a large programme of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived highly radioactive waste for the indefinite future*".

RCEP chairman, Lord Flowers has recently set the 1976 statement into today's context:

"..... a method to ensure safe disposal for the indefinite future - namely, underground storage - has been demonstrated beyond reasonable doubt in other countries, especially Finland."

Lord Flowers in a House of Lords debate – 12th January, 2005 (Hansard)

It would therefore seem that there is a solution to waste. This is certainly the Fuellers' view – it was an abdication of ministerial duty when John Selwyn-Gummer terminated the search for a new nuclear deep-waste repository site in February, 1997. One never hears it said that "the new radiological department at the local hospital cannot be built until there is a solution for the waste", even though 95% of nuclear waste by volume is not from civil nuclear power. One never hears it said, either, that "the six new *Astute* class submarines cannot be built until there is a solution for the waste", even though we have 11 old nuclear boats awaiting full decommissioning; facilities to hold these boats at Rosyth are full and Devonport will be full by June, 2006[50].

The identification of a site for nuclear waste storage is clearly a task for central government – a most pressing task. Many components of the ten million cubic metres of highly toxic industrial waste produced by the EU each year, such as heavy metals, is toxic *forever*. By contrast the mere 500 cubic metres of high level nuclear waste produced by the EU each year has a lifespan; its radiotoxicity decays and in the very long term it is the toxicity of the non-radioactive elements within it (normal toxic waste) that will become more important.

We believe that nuclear operators should be made to put aside the correct best-assessed costs for nuclear waste and decommissioning liabilities, as should CO_2-sequesterers in respect of CO_2 waste storage long-term liabilities management, but that the state should be the ultimate long-term guarantor, in line with international practice.

Approaches for funding the long-term liabilities of decommissioning and waste disposal for commercial power reactors, based on a levy for each unit of electricity produced, are in place in a number European countries including Sweden, Belgium, Germany, Spain and Switzerland. These allow the reactors' owners to build up a fund during the operating life of the reactor by setting aside a small amount of money which is typically about £1 per MWh of electricity produced. The Government and nuclear regulators are generally involved in overseeing how the fund is managed. As the fund accumulates, the future spending plans are regularly updated such that the levy rate can be increased if necessary in order to guarantee that sufficient money is available at the end of the reactor's operating lifetime. Conservative assumptions are used. A PWR could be expected to accumulate about £1Billion over its life – more than sufficient to fund the liabilities which have built up over time.

[50] www.fuelforthought.org.uk/- see link to Howard Mathers' presentation

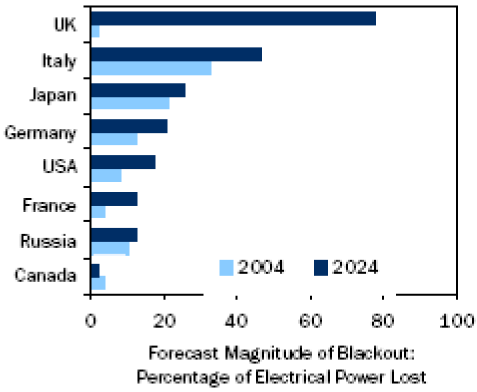
In terms of waste volumes: the efficiency, small size and design of modern reactors means that the amounts of operational and decommissioning waste, and of spent fuel, are an order of magnitude less than earlier UK designs. The total lifetime quantities, over 60 years, of higher activity wastes and spent fuel from a programme of ten standardised international design nuclear stations will add less than 10% to the volume of existing materials that the UK is already committed to managing (source: Gordon McKerron of the committee on radioactive waste management).

Waste should be stored in an accessible manner, whether above or below ground. High-level nuclear waste from nuclear fission may in future be subject to transmutation to destroy it, probably using the high-energy neutrons from a fusion reactor – as a bonus, this could generate more energy in the very process of destroying the waste.

4.11 Can Security of Supply be quantified as it arises from the default future Fuel Mix?

The House of Lords' major July 2004 report on energy issues[51] stated (para 2.5) that by 2020 we will be reliant on imported gas, "more than half" of which will come from Russia. "Interruptions in these supplies may occur once every 8 years with a duration of the interruption of up to 180 days: The UK can at most only store 14 days' worth". Their Lordships urged urgent [but unspecified] action. The Fuellers understand that their Lordships used, in this work, the eminent Professor John H Gittus, who leads underwriting work at Lloyds Syndicate 96 (Chaucer Holdings) - among other energy facilities, Chaucers insure almost all the world's nuclear power plants (excepting only the un-insurable RBMK models). Professor Gittus is well known to us as he has spoken to us and our guests on this very topic at the Fuellers' very successful November 2004 Energy Security Conference, as well as at the February 2006 CBI-TUC conference alongside the minister, and in print in "*POWER UK*" in March 2004 and February 2006. Some of his detailed studies, including the conclusion cited by the House of Lords, can be found at www.gittus.com. The following graph summarises his findings:

Fig 8: Blackouts that are Forecast to Occur with 2 to 5% Probability in 2004 and 2024



Source: Gittus

51 www.publications.parliament.uk/pa/ld200304/ldselect/ldsctech/126/12604.htm#a2

4.12 Barriers to Replacement Nuclear? – The Planning Issue

Lack of advance nuclear design licensing (as now) seriously damages the economics of nuclear replacement-build. In future UK nuclear regulation, advance reactor design licensing is essential. Constructors of new aircraft do not require detailed licensing in each of the 160 nations in which they might land. The current situation where a developer of replacement nuclear power would have to license or gain consent for both a new design (licence or certify it) and site at the same time is wholly impractical, greatly increasing risk and planning timescales and hence finance costs. However, the advance design licensing process in the UK for the leading replacement nuclear designs that is urgently needed and should be brought in at once, should make due allowance for a public-participative element.

The new process should give rise to conclusive and full pre-licensing (or rejection) / certification and hence a conclusive certification of suitability (or otherwise) – it should **not** merely be a general, inconclusive technical review. This latter would be a waste of resource, and actually hinder a site-specific application – not that any applications are likely until the barriers are removed.

At present, we have heard that the Nuclear Installations Inspectorate is 30 staff below its intended staffing levels, which is not helpful in this context. NII staff are underpaid in relation to their special nuclear skills. It is said that the rigidities of pay structures within the HSE prevent this being addressed; without it being addressed, recruitment to the NII is hard. A solution must be found urgently – perhaps taking the NII outside the HSE entirely.

Planning processes need to be streamlined, with far greater certainty on decision-making timescales (a common need for all major infrastructure projects but one which impacts particularly on replacement-nuclear).

Returning to the Sizewell B planning enquiry: of 200 enquiry-meeting-days only 30 were spent on local issues. The remainder were spent on matters of economics and national need. The DTI should make any required justification determination for replacement-nuclear-technology in the context of national energy policy arising swiftly out of this review.

4.13 Barriers to Replacement Nuclear? – The Land Issue

There is a very limited supply of sites suitable for replacement nuclear build. Nothing should be done in the Fuellers view that would preclude development of replacement nuclear plant at existing nuclear-licensed sites, whether now-operational or not. Necessary road accesses for heavy loads must be kept open; National Grid must not be permitted to demolish transmission lines into former Magnox sites (understood to be already under consideration at one site); the NDA must not dispose of the non-care-and-maintenance (non-reactor) balance of land at these sites for other uses.

Fuellers believe that the government should, in any legislation passed as a result of this review, take the opportunity to actively remove all barriers to the early release for replacement-nuclear of those former civil nuclear power sites now in the hands of the NDA, and those that will reach the NDA's hands in the future – two this year, for instance. The NDA has no need during the 100 year care and maintenance stage to hold onto anything more than the nuclear island site (the reactor building), and should be able to release the rest of the land with the turbine hall area.

We have absolutely no view or knowledge of suitability of particular sites. We note that at one of the first-decommissioned sites, based on the public BNFL web site, apart from the reactor building (in long-term care and maintenance), almost everything except the ILW store are already cleared, and that at two sites ceasing generation during 2006, the turbine hall area will likewise be clear within 4 years. There may be no clear means of release (sale, to the taxpayers benefit) of the "clean" balance of site for replacement nuclear. Given the complexity of all that goes with the NDA, this may need legislation, and if so, that should be passed at once.

The American concept of a bank of sites labelled as suitable for replacement-nuclear by the government, and held undeveloped ready for the future, may have merit.

4.14 Barriers to Replacement Nuclear? – The Long-Term Offtake Issue

It has been said by some that very long-term off-takes between UK large consumers and putative new large generation plant may not be permitted. This is concerning as these contracts would in no way be anti competitive, provided all consumers in the sector have access to such contracts if they are interested. The possibility of such contracts may be very useful to facilitate replacement plant being built, and must be allowed for with a clarifying statement from the authorities.

4.15 Energy From Waste, and Biomass at Fossil Plant and in the Home

The Fuellers particularly welcome the recent initiative of the government to better recognise and promote the benefits of Energy-from-Waste, a clean technology that can be relatively economic and practical in its scale. There is a perception that energy-from-waste facilities are of necessity large and intrusive. This is not so. They can be built in modest-sized units that, nonetheless, discreetly and quietly produce worthwhile amounts of power (for example, in the 10's of MWs). There is a perception that energy-from-waste means that greenhouse gases are being added to. Yet in fact, if organic materials are placed in landfill, unless the methane that arises from their decay is itself collected and combusted, the result can be an INCREASE in greenhouse gases since the resulting methane is a 21 times more potent greenhouse gas than the CO_2 that would have arisen from combustion.

We would like to see a reversal of the presently-planned reduction under the renewables obligation, of the cap on "co-firing" of biomass at coal-fired power stations, to further encourage the development of green fuels and their use to beneficially-displace some coal burn. We would also support the extension of the renewables obligation to become a broader low-carbon obligation or a mechanism to provide a long-term and equitable price for carbon, to enable large-scale deployment of low carbon coal technology and CCS alongside other bulk low-carbon options.

There is one area in which the new Building Regulations act against both the alleviation of fuel poverty, and a reduction in carbon emissions. Customers are being driven away from solid fuel as a matter of policy. They are effectively being prevented from choosing solid fuel due to the appliances and infrastructure not being permitted in new-build homes. People are thus forced to use more expensive oil, imported gas or electricity. Customers who at present use these more expensive fuels are being prevented from switching to cheaper solid fuels which, in the case of logs, are often locally available for free and would otherwise be left to rot and emit methane, a very severe greenhouse gas. Given constrained gas supplies, this is also causing security of supply concerns.

As many solid fuel appliances are designed to be multi-fuel and also burn logs or wood products of various kinds, this is also acting to prevent a net reduction in carbon emissions. Customers burning gas are being prevented by the Building Regulations from switching to a cheaper alternative which would result in a net reduction in carbon emissions.

Government should urgently review the way the Building Regulations operate and are being applied to ensure customers are able to have a free choice to seek the lowest cost alternative.

4.16 Capacity Tickets Not Required; Long Term Carbon Pricing

The Fuellers do not believe that the forward market or the imbalance cashout price mechanism in NETA are themselves flawed or are a barrier to new investments. We do not believe that capacity payments mechanisms are either desirable or necessary. See section 5 on Regulation for more details.

The reason the UK has 13 GW of consented new CCGT plant, declining capacity margins, yet with nothing reaching financial close and being built, is due to the lack of long-term carbon pricing policy – this is needed to facilitate the construction of all technologies. Long-term carbon pricing policy should be equitable and should not “pick future winners” – the goal is for CO_2 reduction, not for MW quota from this, or that, technology. This means no RO or CCL in the future. Barriers to any technology options wherever identified must, however, be removed where policy/regulation changes can assist.

Diversion of resource to a new capacity pricing mechanism, which was rightly ruled out in the 2003 Energy White Paper, would be a distraction from putting in place a long-term, equitable carbon pricing framework.

The recent increase in offshore oil and gas taxation was not helpful in terms of prospects for investment to maximise total UKCS oil and gas production.

4.17 Transport

4.17.1 A General Plea

The Fuellers would encourage government to give adequate attention to the growth in energy use related to road and, especially, air transport. Government should consider how a range of policies may have added to the increase in air and road transport usage. In particular, the lack of environmental pricing on air transport combined with cheap runway landing slots has lead to a situation where air tickets can be had on occasion for a few pounds. If government really does finds it impossible to increase the existing aircraft ticket tax to better reflect the very serious environmental externalities being caused[52], or implement any other equivalent policy, it could at least achieve some effective pricing more subtly by not encouraging or permitting the development of further runways. The constraint on runway landing slots would over time cause a rise in price of slots at auction, impacting on ticket prices. Hard-hitting public education may also be helpful – most people probably simply do not realise that one couple making one long-haul flight have caused the emission of as much or more CO_2 than their entire annual use of a motor car. The general public does claim, when polled, to be very concerned indeed about global warming – the link with air travel is simply not being brought directly home to them through either pricing, which is the best way, or – failing that – education.

4.17.2 World Reliance on Petroleum/Oil in the Future

The issue of reliance on petroleum/oil is not only a strategic one for the UK, but for the world. There is growing concern about the world's reliance on oil, particularly for road and air transport where primary energy usage continues to grow rapidly. This rapid growth will continue, even if Westerners were willing to abandon the cheap air travel and personal motor cars to which they have become accustomed, as the peoples of the developing world will also seek the freedom that comes with easy travel. The estimated growth in the world fleet of vehicles is from 900m in 2010 to 1,500m by 2050 (from the Guardian, Friday September 10, 2004).

4.17.3 Alternative Fuels – Detailed Considerations

The search is on for alternative road and air transport fuels that could meet mankind's need to travel without excessive cost whilst also reducing the CO_2 emitted. There are at present an extremely limited number of candidates, mainly alcohols and hydrogen.

Hydrogen is not a primary fuel in its own right, as it has to be manufactured using energy from another primary fuel, which may or may not emit CO_2 and

[52] A fully-laden jumbo achieves just 30 miles per gallon per passenger – the same as a single-occupancy vehicle

other pollutants. We discuss means of making hydrogen, and the economics and carbon implications of the various approaches to this below, alongside the considerations for bio-derived alcohols.
Hydrogen *at point of use* has the merit, widely-commented-on, that it produces only water when used to generate electricity (to drive wheel-motors) from a fuel cell, but in a combustion engine it would again produce some particulates (there would be fewer of these emissions than from alcohol, as the fuel has no carbon content), NOx, etc.

For road transport, ethanol and biodiesel both have serious drawbacks of economics and limited ultimate scaleability, but offer some significant immediate benefits given their ability to substitute freely for existing road fuels with only very limited and in many cases, no engine modifications. The tax differential benefit for ethanol alongside the effect of the new Renewable Transport Fuel Obligation, should assist the UK in meeting the EU's 2010 target of 5.7% biofuel use in our road transport.

Ethanol can be substituted at once for petrol with minimal (almost no) change to distributional, forecourt or existing motor car infrastructure. This is already happening with recent national press reports of Tesco substituting up to 5% ethanol into its forecourt petrol in Southern England, and reports in parallel of new ethanol plants e.g. in South Somerset. Given that ethanol has only 60% of the energy content per litre of petrol, it would seem only fair to inform the motorist clearly of this as, for increasing ethanol content, miles-per-gallon will fall accordingly.

However, productivity questions arise when ethanol is considered as a very large scale substitute due to the relatively low productivity in terms of total plant bulk of wheat, or even of sugar cane and sugar beet, and the relatively low proportions of the plant mass - about 5 per cent - that can be converted to sugar, the only means of producing ethanol. Further, it is necessary to distil the ethanol to high purity which is (moderately) energy-intensive; it is the distillation which is the primary reason why ethanol cannot compete with petrol without the 28 p / litre tax differential advantage.

Methanol has much greater longer-term potential due to its inherent advantages over ethanol. Specifically, the plants grown such as miscanthus and willow are far more productive in tonnage per year than sugar crops (wheat or beet, in the UK) and can be grown on much lower-grade or less accessible, non-arable land. Moreover, the proportion of the plant mass that can be converted to methanol is far higher, as high as 50% because the woody ligno-cellulose matter can be bacterially fermented. Furthermore, the methanol only needs to be distilled to a concentration of 50/50 methanol/water, because a tantalum-based mixed-oxide fuel cell can convert it at this concentration direct to electricity to drive a motor with a very high overall efficiency - a prototype vehicle of this type has been produced, and the consultants CERA have produced a promising private report on this technology. Distillation to a concentration of just 50/50 methanol/water is immensely beneficial in reducing the energy used in distillation to high purities (as is the lower boiling point of methanol – 60 degrees, against 79 for ethanol), and use in a fuel cell in this manner can totally eliminate local NOX and particulate emissions. Methanol fuel cells are also exciting strong interest recently in other sectors[53] as a fuel for tiny portable mobile telephone/computer batteries, and for use by soldiers to power their communications/navigational equipment.

However, methanol can be utilised in a spark-ignition (“petrol”) engine just as ethanol can, but with far more extensive modifications. The methanol is not as readily miscible with petrol in varying proportions so it would be used as pure methanol. Alcohol fuels (ethanol and methanol alike) in petrol engines tend to cause the engine to run cooler, reducing somewhat the nitrous oxide emissions compared to running on petrol. Methanol is corrosive to rubber, which is one of the reason existing spark engines (and forecourt vending apparatus) would need more adjustments to be able to run on it.

Methanol can also be utilised in gas-turbines and so, subject to a safety case, could readily be used as a renewable fuel for jet, or turbo-prop airliners as well as small spark-engined light aircraft; this is most certainly not possible to envision, for safety reasons (and because of the great weight associated with its tank-containment), using hydrogen[54], although a tiny unmanned hydrogen-powered plane was tested last year.

Naturally the CO_2 emitted from fermentation and use of methanol/ethanol was mostly absorbed by the growing plant. Indeed, given the bulk of unusable plant materials arising, the plant will have absorbed a good deal more CO_2 than that so emitted; the remaining bulk would almost certainly be dried and burnt as biomass in power stations, beneficially displacing the use of fossil fuels.

Electric road vehicles are a theoretical possibility offering zero emissions at point of use, but cannot meet expectations of performance and range in the absence of a significant innovation in battery technology which has not been forthcoming these last 100 years. Hybrid petrol-electric vehicles, in theory securing “the best of both worlds” at the expense of somewhat more prime mover components in total, have in practice been an extremely expensive gesture so far rather than a practical and economic proposition for most people, being chosen by the likes of public officials as an environmental gesture at others’ expense and by the wealthy, but do certainly offer much-improved fuel economy with reasonable, if not exotic, performance.

Biodiesel is also a promising substitute fuel for compression-ignition (“diesel”) engines but again the yield of biofuel per hectare falls considerably short of that possible when producing methanol from appropriate crops, so its ultimate scale is limited.

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[53] http://www.timesonline.co.uk/article/0,,25689-2010449,00.html

[54] Hydrogen is rather energetic, can only be contained at enormous pressures e.g. 600 bar, and leaks readily through the tiniest gap. It is explosive when ignited, even at very low concentrations in air, remaining explosive up to very high concentrations of hydrogen.

Hydrogen at the very best (in maintained-very-cold, i.e. cryogenic, liquefied form) can only achieve an energy density of 10% that of petrol, or 7.6 % in compressed (to a massive 600 bars of pressure) unchilled form - and appears a somewhat impractical fuel for road transport for these reasons, as well as being utterly unfeasible for use in aircraft for reasons both of safety, and of the weight of its containment.

We believe that ethanol and methanol with just a small amount of help in recognising the value of their renewable status, can provide very major reductions in transport-related CO_2 emissions, particularly given their eminent suitability (as distilled, pure fuels) for use in aviation transport (in gas turbines). Methanol appears to have the best long-term scope.

Where there may be far more practical scope for actually using hydrogen is in a mixture with methane on the gas grid, to substitute in energy content terms for some of the methane – this mixture is known as hithane[55]. We would like to see more research on the feasibilities of hithane, and also of syngas substitute as derived from coal (syngas would be suitable for dedicated use in CCGTs but not for use on the gas grid).

We explore the storage options (for motor cars) and production techniques and economics generally of hydrogen in more detail in Appendix 3

[55] www.sustain.ubc.ca/sustainable_u/documents/A%20Sustainable%20Climate%20Policy.pdf

5. Regulation

Fuellers would like to make the point that regulatory stability is a key ingredient of a successful market. This stability has not always been enjoyed in the energy sector in practice.

The Fuellers do not believe that the forward market or the imbalance cashout price mechanism in NETA are themselves flawed or are a barrier to new investments. We believe that the solution lies with the market; adding extra complexity to the NETA-and-forward-price-market (taken as a whole) will not alter investment incentives in new generation plant, as the market price depends on the extent of concentration/market power in generation, and the prices of the fuels. Changes to the market mechanism would not affect these fundamentals, but could make the market significantly more complex. The added complexity would both create gaming opportunities, as we saw in the Pool and have seen in the generation market in Spain, and would make the market less attractive to both existing smaller, independent generators and to generator and supplier new-entrants – this effect is clearly undesirable.

Exit auctions and changes to gas market regulation:
There have been quite a number of changes to gas wholesale market regulation these last six months, and a little earlier we saw very significant proposals to introduce exit capacity auctions. These auctions were opposed by most in the industry and demonstrated in analysis by the economic research consultancy *NERA* to have a negative cost-benefit. The exit capacity auctions have been deferred for the time being, but with a signal from Ofgem that they will be brought back in the near future. Changes to market mechanisms should *only* be introduced when there is a clear requirement for them with support from at least a significant proportion of market players and customers (or their professional representatives).

Electricity imbalance cashout prices:
There have been a number of changes, some quite fundamental, to the imbalance cashout price for electricity since the NETA market commenced on 27th March 2001. Further changes would not be desirable unless a strong case were made with support from at least a significant proportion of market players and customers / professional customer representatives. Changes should perhaps not be made that make the sector more risky for smaller firms to operate in, riskier for all participants, or which exacerbate "gaming" opportunities for generators controlling marginal, higher-priced generation.

Fuel security code:
The "fuel security code", affecting the possible state-directed operation of UK generators during an emergency and their reimbursement for the same, is currently inoperable. This is because the present version of the code refers to the Pool, the Pool Funds Administrator, and does not make clear cost-recovery and other issues. A consultation was held closing August, 2003 on how to update the code. Two years elapsed with no resulting Code update, and another consultation was then held late in 2005. The code remains out of date and in, in some respects, inoperable condition. This increases

uncertainty for investors and operators in the sector, and should be resolved as a priority.

Offshore oil and gas taxation:
The recent increase in offshore oil and gas taxation was not at all helpful for investor confidence in that sector in terms of maximising total remaining UKCS investment and may affect confidence in investment in gas storage[56]. However, the area of gas storage is a little unusual and may comprise an exception to our general plea for less intervention: we accept that there may need to be some national lead or state facilitation, perhaps through a "storage obligation", in order to ensure that investment is made in the badly-needed strategic, i.e. large-scale ("Rough Mark 2", as some would say) UK gas storage.

Surface Mining
The UK has several hundred million tonnes of coal reserves that could be economically extracted by surface mining, enhancing our national security of energy supplies in the process – as well as our balance of trade. The greatest impediment to production is the increasing difficulty in obtaining planning permission. Planning guidelines in England apply a presumption against approval for surface mining unless strict conditions are met. No such presumption applies to any other form of mineral extraction. It is discriminatory - and most unhelpful at a time when indigenous fossil fuel production is declining.

This presumption against has recently been introduced in Scotland. At the same time, the new Scottish guidelines introduced a 500m buffer zone - as opposed to the 200m that applies to some other minerals. This will sterilise large areas of coal reserves, eliminating a number of potential sites completely. Draft planning guidelines in Wales propose a 350m buffer zone which will have the same effect. Arbitrary fixed buffer zones are not based on any objective criteria and should be replaced by ones which are assessed on site-specific criteria for each application.

Fuellers are most concerned that mineral planning authorities in England are not taking proper account of the planning considerations that enable the "presumption against" to be overcome.

This competitive ratcheting-up of requirements across the devolved administrations and amongst mineral planning authorities is strangling surface coal production just at a time when the UK wishes to become more self-reliant in energy terms, as is clearly shown the by the MORI poll we cited in section B, early on, and just as our own UK gas production winds down. Surface coal production has fallen from 18m tonnes a year to 10m tonnes a year over the past decade. The Government must remove the "presumption against" when surface mining applications are assessed, to replace arbitrary buffer zones with ones assessed on site-specific criteria, to ensure that mineral planning

[56] See page 27 of The Economist, 18th to 24th March 2006

authorities properly apply planning guidance and to ensure, on energy policy grounds, that a similar regime applies throughout the UK.

Planning guidelines for some other minerals require a landbank of future permissions to be maintained so that the nation's need for essential materials can be met. There is a market for coal in the UK substantially in excess of indigenous production and import capacity for internationally sourced coal is tight. Over the past winter, coal-fired generation provided over 50% of UK electricity and indigenous coal was a major component of supply. Without this level of generation, electricity supply difficulties would have occurred. There is a need for indigenous coal production which should be taken into account as an important national consideration when applications for surface mines are considered. We urge the Government to adjust planning guidelines accordingly – across all of the UK.

Surface mines are also subject to Government imposed cost pressures that do not apply to the UK's international competitors. Recent increases in the duty on off-road diesel have increased costs significantly. The level of duty is well above the European minimum and does not apply to non-European competitors. When considered in conjunction with the climate change levy, this amounts to double taxation. Gas oil used for electricity generation has recently been made exempt for this reason. The Government should consider introducing a similar exemption for diesel used in the production of coal fuel, which is mostly linked to electricity generation anyway.

We emphasise again, that the market, to invest in much-needed new generation in particular (of whatever technology), requires stable, long-term, equitable pricing of carbon; together with the removal of other artificial barriers, this will allow nuclear, renewables and coal-based options to compete on a level footing.

The ETS (emissions trading scheme) scheme in the current phase does not allocate full lifecycle equivalent carbon emissions and therefore gives particularly (erroneously) low emissions formally to CCGTs, and it gives free allowances to new CCGTs. These mistakes must not be replicated in ETS Phase II, nor should ETS Phase II run alongside other narrow and incoherent technology-specific carbon pricing schemes like the renewables obligation or the climate change levy exemption certificate (LEC) scheme.

6. Conclusions

In summary, the Fuellers believe that Britain will need to pursue virtually ALL aspects of the solution to the energy dilemma. This means abolishing the costly Renewables Obligation and Climate Change Levy (as they would affect future investments, at least), and replacing them with a unified, equitable, strong LONG TERM carbon valuation that would allow sequestration, nuclear and renewables options to compete alongside clean coal and CCGTs on a perfectly equal basis. Carbon should be priced into the market on a full-lifecycle basis including for example the LNG process where this is the fuel source and the carbon-equivalence (CO_2-equivalence) of methane leaks, which is crucial. A result of this would be that the UK would have a more diverse mix than the “default” arising from present energy policy (which would be almost entirely an imported-gas-fired generation fleet by 2023, with some small-scale renewables).

The UK’s solid fuel inheritance should be properly used, and we have made detailed suggestions that could aid surface-mining – including the removal of the discriminatory “presumption against” when assessing planning applications.

Fuellers passionately believe innovation is key to the UK’s success and note that UK spending on R&D in energy projects falls a very, very long way behind that of competitors such as France and Japan. Fuellers believe the UK needs a real and strong **policy for innovation and research**. We ask for more research monies for innovative low-carbon research. We note particularly that the **NFPA surplus fund** has been predicted by POWER UK to reach £1 billion by 2008, with no clear means for its release for innovative low-carbon research or innovative low-carbon project capital support. It **is essential that the means for its release for innovative low-carbon research or innovative low-carbon project capital support is put in place in any legal instrument that arises from this review**, just as was done in the 2004 Energy Act to facilitate the release of the first £60m of the NFPA surplus fund.

Security of supply concerns are real and as well as removing barriers to replacement nuclear and sequestration, we believe that all new CCGTs should, as a condition of their planning consent, have generous (many days) on-site stocking of liquid fuels and the ability to burn them must be maintained by the CCGT operator.

We would like to see this NFPA surplus and other funds, used for research into key areas such as the potential for **hithane (use of hydrogen to substitute for some methane on the gas-grid)**, **methanol as a future road and air fuel, sequestration, clean coal technology, coal gasification including subterranean gasification - and “generation IV” nuclear fission technology, where there is currently no UK government funding at all.**

In terms of maximising total remaining oil and gas output from the UK Continental Shelf, the recent increase in offshore oil and gas taxation was not at all helpful and has damaged investment confidence in the UK energy sector significantly.

We particularly hope that a **working full-scale CO_2 sequestration prototype project** will become possible (this may need government enablement) to give a much clearer notion than is possible at present, of the real costs, potential and practicality of this promising technology.

Fuellers believe that the government should also, in any legislation passed, take the opportunity to **remove all barriers to the early release of those former civil nuclear power sites** now in the hands of the NDA, and those that will reach the NDA's hands in the future – two this year, for instance. The NDA should focus on the nuclear island site (the reactor building), and release the rest of the land for replacement nuclear projects. There is at present no clear means of release (sale, to the taxpayers benefit) of the "clean" balance of site for replacement projects. This may well need legislation.

We emphasise again the acute importance of transport, **especially aviation**. If transport, including aviation, continues to be in reality neglected, we cannot solve our problems even with a 100% zero- CO_2 generation fleet.

Overall, we encourage the use of *technology-based solutions* to the challenge of cutting emissions, and support the development of a UK capability base which will ensure that such solutions are able to be delivered. This statement applies to nuclear power, advanced coal technologies, **energy efficiency including the "smart metering" enabler,** aviation and road transport options; and renewables including tidal barrage options; **Fuellers believe that the UK is likely to need ALL of these options to meet the immense, extremely difficult challenges of the future.**

On the **demand side**, we support a balanced approach to **energy efficiency**, which looks at the true costs and true overall benefits of different options. Large-scale behavioural changes are VERY difficult to achieve without legislation or energy price pressure (although recent price increases will help make measures more cost-effective).

Specific policy/regulatory measures which could be helpful might include:

- Strong incentives for "smart metering" – so householders and businesses can see the real-time costs of their energy usage. This may necessitate a move to metering as a regulated service – competition-in-metering as a model may struggle to mass-deliver smart metering.

- Legislation to reduce energy wastage (more efficient appliances, self-switch-off appliances to reduce "standby" losses)

- Enforced, effective rules to ensure that new housing and new commercial developments are built to the very highest energy efficiency standards. Effective legislation forbidding the routine leaving-on of all lights in empty retail and commercial premises.

- Sustained communications to inform the public why energy prices will inevitably be rising over coming years, as we import more energy and pay a premium for reducing carbon emissions. This message should include education on ways to save energy, and on which are the low-carbon power generation technologies. Fitting all primary schools with small wind turbines (a current policy goal) if not mentioning the pro's and con's of wind against other low-carbon power generation technologies (costs, scale, intermittency), does *not* comprise a balanced, scientific, unbiased education; it would represent a shallow, and not a holistic, education.

- Investment in R&D for development of more energy efficient technologies including in transport, which is an increasingly significant contributor, accounting for around one quarter of total UK CO_2 emissions.

- The domestic burning of logs for heat can be beneficial both environmentally and in terms of reducing national energy import-reliance. Government should urgently review the way the Building Regulations operate and are being applied in respect of the energy facilities within new-housing, to ensure customers are not prevented from being able to burn logs.

- New building codes for gas distribution should use material that is suitable for conveyance and control of hithane and hydrogen.

UK Industry is crippled by a perverse Climate Change Levy that taxes output from low carbon nuclear sources at the same rate as carbon-intensive coal- and gas-fired generation – this is coupled with a complete absence of equivalent taxation on electricity and gas use in the domestic sector. Fuellers call for the abolition of the Climate Change Levy, **or** that the same exemption from the Levy that is given to certified consumers of carbon-emitting CHP plant, should be given to certified consumers of virtually-non-carbon-emitting nuclear plant.

In **nuclear regulation**, the current situation where a developer would have to licence both a new design and site at the same time is wholly impractical, greatly increasing risk and planning timescales and hence finance costs. However, the **advance nuclear design licensing process** that is urgently needed and should be brought in at once, should make due allowance for a **public-participative element.**

The new process should give rise to conclusive and full pre-licensing (or rejection) / certification and hence a conclusive certification of suitability (or otherwise) – it should **not** merely be a general, inconclusive technical review. This latter would be a waste of resource, and actually hinder a site-specific application – not that any applications are likely until the barriers are removed.

It has been said by some that very long-term offtakes between UK large consumers and putative new large generation plant may not be permitted. This is concerning as these contracts would in no way be anti competitive, provided all consumers in the sector have access to such contracts if they are interested. The possibility of such contracts may be very useful to facilitate replacement plant being built, and must be allowed for with a clarifying statement from the authorities.

The Fuellers would like to *again* urge that the government, considering the sectors of most extreme national CO_2 emissions growth, should be paying the most attention by quite a long way to aviation, then road transport, then other sectors including electricity generation/consumption and the domestic/other use of other fuels. In reality, the present situation is essentially the opposite of this; aviation appears to be regarded as an almost irrelevant embarrassment with no sense of urgency, little discussion and no powerful or immediate policy measures to address the matter.

This review is not a nuclear review, and the Fuellers response is, accordingly, not a nuclear response. However, we do note in closing that nuclear energy is, by far, the biggest proven provider of large-scale low-carbon electricity in the UK, yet the current market and regulatory/legal environment do present artificial barriers to the deployment of this technology. If these barriers are reduced, through design certification and long-term, equitable carbon pricing, nuclear energy, and other technologies such as tidal power and fossil fuels with carbon capture, will have the opportunity to play their part in helping to reduce carbon emissions alongside the realisation of energy efficiency through building regulations with teeth, and the addressing of aviation through thoughtful measures that go beyond “let’s build some more runways”.

The Worshipful Company of Fuellers places on record its appreciation of all those individuals and organisations who have contributed to this submission.

APPENDIX 1

Desalination-Related Future UK Energy Demands

Even the more modest 2004 government proposals for 1 million new homes in the South-East and Eastern England would need (the water industry has suggested[57]) new desalination plant, as there are no sites for new reservoirs and existing water capacity is utilised. The National Rivers Authority (NRA) has predicted a deficit in supply by 2021, in the Severn Trent, Thames and Anglian regions, if there is a medium growth in demand, with severe stresses after 2010 in certain regions such as the Thames. Such desalination plant, not previously needed in the UK, would have unprecedented energy demand implications. Desalination is energy-intensive: the widely-used multi-stage flash (MSF) and multi-effect distillation (MED) desalination techniques require between 25 and 200 kWh per cubic metre of water (the reason for the wide range is that the more efficient techniques tend to have drawbacks on cost and feasibility in some situations). UK water consumption is about half a cubic metre per person per day[58].

If sufficient desalination plant were built to entirely supply the 5 million new homes to be built by 2026, the new plant would thus need between 63 and 500 TWh of energy. To give a sense of scale, this is an extra annual energy need equivalent to between 0.2 and 1.5 times the existing UK electricity demand – the exact figure depending on the relative practicalities/economics of the differing techniques.

Ideally, zero-carbon heat should be used to meet the unprecedented energy demands of these new desalination plant.

The UK's environment agency has increasing concerns over cooling water discharge and is imposing much tighter restrictions than in the past. For example the oil-fired UK power station, Littlebrook, on the Thames at Dartford (constructed in 1982), is now facing a new restriction: it is only permitted to generate from one of its three units at any one time, even at times of national shortage of power. Incidentally, it would be rather sensible to have in place a clear framework allowing, without need for further bureaucratic approval, relaxation of such constraints at times of short generation nationally as signalled by, for example, one of National Grid's official warnings to the market. Any means of reducing heat discharge to seas and rivers, for example using the waste heat for desalination, is thus of more value than before – but is likely to be feasible at coastal generation sites with adjacent land – these are all nuclear.

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[57] e.g. BBC radio 4 programme devoted to this topic, broadcast early evening, Sunday 24th July, 2005
[58] www.optimumpopulation.org/opt.more.water.html

There is certainly scope for use of waste heat from nuclear power stations: The BN-350 fast reactor at Aktau, in Kazakhstan, successfully produced both electricity and potable water over some 27 years. In Japan, some ten desalination facilities linked to pressurised water reactors operating for electricity production have yielded 1000-3000 m^3/day each of potable water, and over 100 reactor-years of experience have accrued. The MSF desalination technique was initially employed, but MED is now preferred there. Pakistan plans a desalination plant coupled to its KANUPP reactor near Karachi. Morocco is also planning nuclear-powered desalination, as is China (at Yantai, producing 160,000 m3/day by MED, using a 200 MW reactor). South Korea and Argentina have each developed competing small PWR type reactors designed from the outset for cogeneration of electricity and potable water[59].

Indeed, the UK has already seen its first formal proposal for a desalination plant, in the lower Thames estuary. Many more will be needed.

[59] Sources : WNA; Konishi & Misra, Freshwater from the Seas, International Journal of Nuclear Desalination, 2003, vol 1, 1; UN World Water Development Report 2003; New Scientist 10/7/04.

APPENDIX 2

History of IRA Attacks on Energy Facilities in the United Kingdom

The United Kingdom only has limited experience of actual terrorist attacks on its energy facilities, and these date from the days of Irish Republican terrorism. This is a list, not necessarily complete, of the incidents in the past:

Saturday 16 October 1976: Three members of the IRA were killed when a bomb they were planting exploded prematurely at Belfast Gas Works, Ormeau Road, Belfast.

Saturday 9 May 1981: the Irish Republican Army (IRA) caused a minor explosion at an oil terminal in the Shetland Islands.

Friday 26 February 1993: the IRA exploded three 25 kG bombs at a gas works in Warrington, England. The bombs caused a “large explosion”.

Friday 23 April 1993: the IRA carried out a bomb attack on an oil terminal in North Shields, England. The bomb damaged a large storage tank.

The electricity cabling from Ulster to Eire was repeatedly attacked and rendered effectively inoperable for prolonged periods of time.

A range of other commercial facilities were attacked including the Baltic Exchange (which was totally destroyed), the bomb attack on Eglinton airfield in which the terminal building, two aircraft hangers, and four planes were destroyed, and an unsuccessful attack using four home-made mortars on Heathrow airport directly before Concorde landed – the shells reportedly launched successfully, but failed to explode or damage the runway.

Since 1995, the rate of attack from this movement fell and then ceased. In 1997 an IRA gang were jailed over an earlier plot to bomb electricity substations around a major UK city. However, much of the key electricity supplies there are located underground and are considered safe from attack.

APPENDIX 3

Storage Options and Production Techniques/Costs for Hydrogen

Hydrogen can be stored – and this is the leading option - in very strong, very high pressure tanks (which tend to be rather heavy, and need to be of cylindrical or spherical dimension), typically above 600 bar. At 600 bar the energy density is 1/13th that of petrol, so together with the problem of tank geometry (which makes it hard to use vehicular space very efficiently), the vehicle is likely to have very limited range and/or luggage space.

Liquefied hydrogen can be stored in cryogenic tanks - essentially large thermos flasks - which need an ongoing supply of energy to totally reliable chillers to keep them super-chilled, otherwise the hydrogen must be dumped out of ports from the vehicle to avoid a pressure-explosion. This is the approach used on BMW’s 2003 prototype. Very serious safety issues then arise if the vehicle is in a confined space such as a garage or enclosed (multi-storey) car park at the time.

Sodium boro-hydride can be used as solid hydrogen storage medium – tanks can be rectangular in form, so although the energy density achieved is about the same as the very high pressure tanks mentioned above in terms of tank contents, more hydrogen can in practice be stored in a given vehicle. There are substantial process losses (inefficiencies) in converting hydrogen to and from borohydride, and a significant process cooling requirement, but the explosion risk during a crash is far less. A safety hazard during a non-explosive-release type hydrogen fire (a fire not preceded by a pressure-explosion due to prompt conventional-high-pressure-tank breach or fracture) would be that hydrogen’s flames are completely invisible in air. This makes it difficult to tell if a leak is burning unless the flames are contacting other material, and so carries the added risk that it is easy to walk into a hydrogen fire inadvertently. Most hydrogen fires would be accompanied by explosive or very rapid hydrogen release from breached high price containment, with at the very least a very rapid conflagration that could not be overlooked. The risk is thus usually theoretical, but this risk could be more real with a leak from a (low pressure) borohydride tank that had found a source of ignition, as the leak would be slower and non-explosive.

Hydrogen could be mixed with methane to create vehicular hithane fuel (see above), which can be slightly more readily contained in the vehicle with resultant slightly better energy densities. Hydrogen could not, however, be mixed with propane (LPG). Being very energetic, the fast-moving hydrogen molecules would remain evenly mixed with the methane (also quite small energetic molecules) where it remains a gas (as methane does at most conceivable pressures, when not super-chilled) of their own accord, but this is not the case for hydrocarbon gases which may become partly or wholly pooled liquids under pressure - such as propane or butane.

Far more speculatively : new materials such as carbon nano fibres into which hydrogen can be absorbed under the combined influence of high pressure and low temperature, to be released as the pressure is dropped and the temperature increased. This has been talked about for 8 years now, but public, concrete non-nano-scale results have been notable by their absence.

We now explore the economic and other aspects of options for hydrogen production (and its existing uses and production) in a little more detail. Hydrogen should of course be produced in a manner that has very low carbon implications.

Large quantities of hydrogen are needed in the chemical and petroleum industries, notably in the Haber process for the production of ammonia, which by mass ranks as the world's fifth most produced industrial compound. Hydrogen is used in the hydrogenation of fats and oils (found in items such as margarine), and in the production of methanol. Hydrogen is used in hydrodealkylation, hydrodesulfurisation, and hydrocracking. It is used in the manufacture of hydrochloric acid, in welding processes, and in the reduction of metallic ores.

Some people argue that hydrogen could be piped in pure or hithane form to people’s homes and be used at 55% efficiency to generate electricity from home fuel cells (e.g. nuclear engineering international – “NEI” - July 2005, page 16).

Most hydrogen today is produced by chemical reformation of hydrocarbons such as oil components (naphtha, heavy residues) and natural gas, although a small proportion is made by electrolysis where either the electricity is very cheap or there is a need for very pure hydrogen.

It is therefore important to note that most of the present industrial hydrogen production methods all release similar volumes of CO_2 to the atmosphere as that of the hydrogen produced. To eliminate CO_2 emissions from the present industrial production methods, carbon capture and sequestration (CCS) would need to be applied, adding to the production cost and reducing energy efficiency.

Closely related to the problem of storage is that of the infrastructure and handling technology at the motor vehicles’ fuel-filling station. Certainly at first impression, if distributed by road tanker, 13 times as many journeys would be needed; this may indicate that piped distribution could be justified above a certain scale (there are a number of cost figures for trucking, and for pipelines, on page 17 of NEI, July 2005, showing when this breakpoint is reached).

There are approximately 25 million cars and 3 million commercial vehicles in the UK using about 54 Mtoe of petrol or diesel each year, resulting in the emission of 150 million tons of CO_2.

If the current UK road transport fleet were to be converted to run on hydrogen, it would need about 7.5×10^{10} cubic meters of hydrogen. Therefore, the UK’s natural gas transportation system is of the same scale of that required for a fully integrated hydrogen economy in the UK.

If all the vehicles in the UK were to be replaced with hydrogen fuelled vehicles, existing UK hydrogen production would have to increase by about a factor of four.

If this hydrogen were to be produced by electrolysis, this would require about 50 GWe of dedicated UK generation over and above the 75 GWe of existing UK power stations.

Furthermore, this would need to be generating plant that does not emit CO_2. Whilst renewables will undoubtedly contribute to this, at the present and forecasted rate of growth, it is unlikely that they will reach 10% of the *existing* generating capacity by 2020, let alone the additional 60% required if a full hydrogen economy is to be implemented by around 2050. Whilst these figures are broad estimates whose details can be debated, they serve to illustrate the magnitude of the “hydrogen economy” proposition and the severe challenges to realise it. The challenge of building an additional fifty 1 GWe zero CO_2 power stations, over those required for electricity production alone, is a major one. France has built sixty such stations in 30 years, but in the UK we probably do not have sufficient sites.

Worldwide: 360 bn gallons of petrol will be used in 2010: this would equate to 260bn kg of hydrogen. To produce that much hydrogen across the world, global electricity production would have to be increased by between 15% and 25% more than that needed merely to keep the lights on.

There are 440 nuclear stations operating worldwide, but providing enough electricity and hydrogen to meet the world's needs might need up to 3,500 nuclear stations.

The Fuellers note that the American government is so convinced that dual electricity and hydrogen production is the future that the US department of energy has now decided to construct a demonstration nuclear reactor to produce hydrogen in Idaho Falls.

The consortium that is producing the pebble-bed modular reactor (PBMR), very well suited to high temperature hydrogen production, aims to have the first prototype operating from 2012. Japan’s “*JAARI*” high temperature reactor reached 950 degrees in 2004 and is particularly aimed at hydrogen production. STAR, the small fast neutron reactor, is also aimed at this but lacks the backers and publicity that PBMR enjoys.

Hans Forsstrom, from the European commission, said the EU was also considering the use of high-temperature reactors to produce hydrogen. The process had a "big potential".

We refer again to NEI July 2005: The maximum feasible net efficiency of low temperature electrolysis-based production of hydrogen is 75%. For a say light water reactor (PWR) operated not entirely at base-load, that achieves 32% real thermal efficiency, the net efficiency of hydrogen production by low temperature electrolysis is then 24% in comparison to the raw nuclear heat. If the high temperature (800 degrees+) steam-based electrolysis was used for the production, using nuclear heat in substitution for some (about 30%) of the electricity, the net heat-to-hydrogen efficiency would be 50%. This process has been tested at a small scale, and work is continuing at Idaho on scale-up.

Low temperature electrolysis-based production is in fact used for about 4% of current US production – hydrogen produced this way costs more than using steam to reform hydrocarbons, but the hydrogen is particularly pure and therefore good for rocket fuel, research, and some other of the more demanding uses. The maximum unit size currently available (because there has not been demand for more) is 2 MWe – each such unit produces 1000 kG per day of hydrogen at atmospheric pressure; the hydrogen then needs compression to say 20 or 30 bars before piping.

The problem is that hydrogen of lower quality, suitable for most processes, produced (together with CO_2) from hydrocarbons costs $1 to $1.50 per kG, whereas low temperature electrolysis-based production gives hydrogen at a cost of $4 to $6 per kG. The cost of high temperature (800 degrees+) steam-based electrolysis should lie in the range $2 to $4 per kG – still too high.

The Japan Atomic Energy Research Institute is testing the Sulphur-Iodine Cycle process at its JAARI high temperature reactor, and claims a bulk production cost of $1.50 to $2 / kG-hydrogen should be possible, directly competitive with feedstock reformation techniques but without the CO_2. This is much talked-about at present; we very much hope that it proves to be achievable.

In terms of the economics and feasibility of hydrogen production from methane with CCS: Natural gas reformers can make hydrogen from natural gas at filling stations or in central plants. But whatever the price, electricity produced directly from natural gas will, arising from the physics, always be much cheaper than electricity made from natural gas–derived hydrogen. A modern combined-cycle power plant is 50 per cent more efficient than a fuel cell vehicle, has access to cheaper wholesale natural gas prices, and does not need to cover the cost of hydrogen production, storage, and distribution. A modern combined-cycle power plant is thus the most energy-efficient way of using limited gas supplies. Central hydrogen generation plus distribution in liquid tankers has similar costs at the pump as hydrogen production at filling stations, and the same logic holds in both cases.

Electricity made from hydrogen produced by electrolysis cannot be cheaper than the original electricity; that would be the economic equivalent of a perpetual motion machine. This is worth bearing in mind if one contemplates using the output of costly renewables plant to make hydrogen, alongside the limited physical total scope for renewables in the UK.