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ENERGY

A sustainable energy strategy for the UK

By Hugh Gouldbourne

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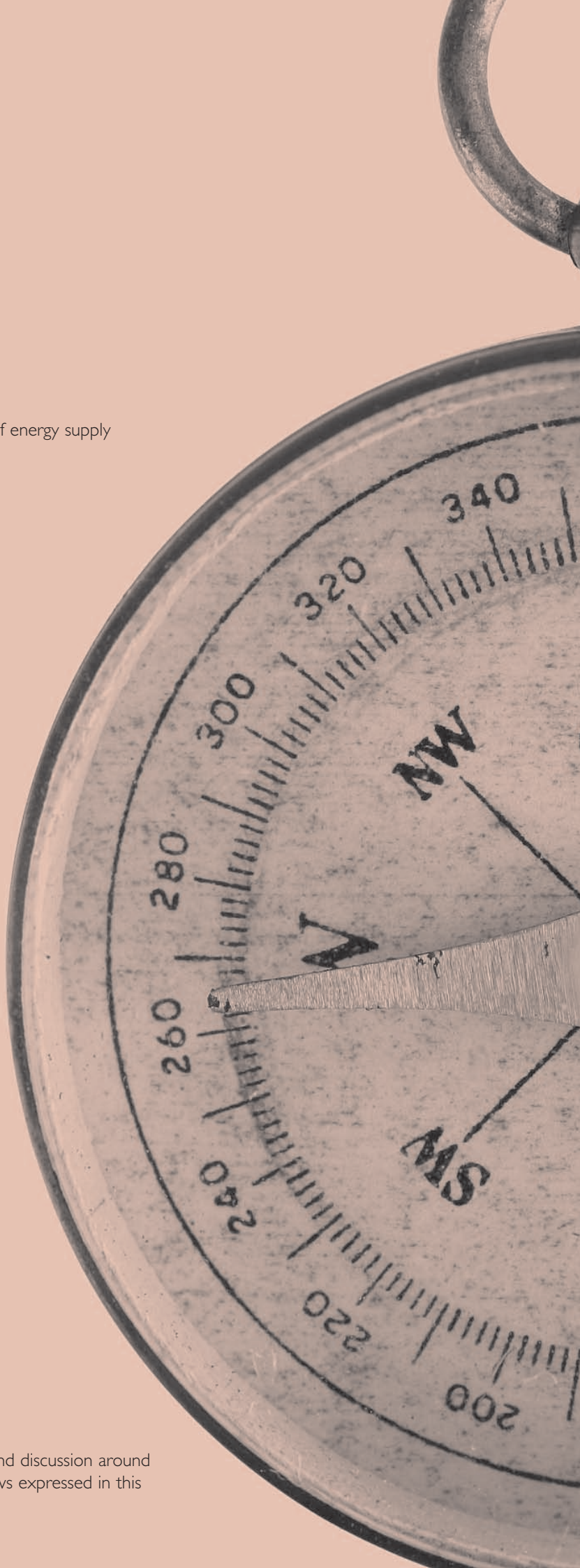
contents

Energy



As energy disaster looms we have to stop rearranging deckchairs and do something effective, something that will actually alter our course dramatically, in time to make the crucial difference.

Professor Walt Patterson

A sustainable energy strategy for the UK

By Hugh Gouldbourne

Compass Thinkpiece 11

1. Summary

The UK is in need of a new energy strategy. We must cease to act in a way which destroys our climate and secure a safe supply of energy for our growing and energy-hungry population. A large amount of intellectual, political and financial investment has been and continues to be spent on debating the formulation of this strategy. In particular the Government commissioned its second Energy Review in four years, the conclusions of which were released in mid-July by the DTI.

The outcome of the review is that the Government will pursue a mix of energy options. This mix will focus on the need for low carbon generation and greater efficiency in our energy usage. The primary infrastructure projects, however, will be the construction of a new generation of nuclear power stations, ongoing usage of gas fired stations and continued investment in developing 'clean-coal' power stations. Energy companies will be urged to launch campaigns to place pressure on consumers and businesses to be more efficient in their energy usage. The Government has expressed an aspiration that micro-generation and renewable forms of energy ("renewables") will be developed but only as long term pieces of the energy puzzle. This modest rhetoric will be matched by equally un-ambitious market regulation and financial incentives aimed at growing the fledgling micro-generation and renewables market.
The Government's approach appears to be informed by the belief that the answer to our energy problems is to update and renovate the infrastructure and technology which currently generates power in this country (i.e., nuclear, gas and coal). As such, the Government has not recognised that the nuclear technology available to us, poses the same problems as oil or gas. It neither allows us to protect against any further damage to the environment nor does it ensure the continued and secure supply of heat and power. Nuclear power has major environmental risks that result from the extraction and disposal of radioactive material. We may choose to externalise these costs on the basis of greater energy security and lower CO2 emissions. However, nuclear energy will, for the following reasons, exacerbate and not solve our CO2 emissions and security issues:

* The raw material (uranium ore) is not available to us in the UK. Therefore, as with oil and gas we are at the mercy of supply routes from abroad;

* New nuclear generators will not come online before 2020;

*∑Our current technology will only allow for the process of nuclear generation to be CO2 free, where high-grades of uranium are used. Current levels of usage mean that unless further reserves of high-grade uranium are discovered then by 2034 the uranium ores that remain available to us would be of such a low-grade that nuclear generation would increasingly become a net CO2 polluting process;

*∑New nuclear will only account for approximately 16% of our total electricity consumption;

* New nuclear will not contribute to our heating or transport energy needs (at least not until we invest the massive amounts of finance and effort in the infrastructure needed for a society powered entirely by electricity or Hydrogen); and the economics of nuclear power means that it is not attractive to private investors and therefore will require substantial government subsidies or guarantees.

As such, we must recognise that to invest the sizeable amounts of public finance, which would inevitably be required for a new nuclear project, would be highly irresponsible. We must also accept that there is no single long-term solution to the UK's energy needs and the Government must instead focus our economy on a mix of reliable and efficient technologies that can be implemented in the short term and then improved over the next 20 years.

First, the Government must be serious about the way in which it tackles energy consumption in the UK. Simply producing leaflets and guidelines for consumers to encourage voluntary reductions will not bring about the large scale change in behaviour that is required. The Government must follow the example of others (e.g., Germany) and put in place the regulatory and financial incentives for businesses to successfully develop and market the low carbon energy technologies that are already available to us. There are a number of ways in which this can be achieved in the industries that account for the majority of our energy use:

(i) Buildings, in particular housing, account for approx 30% of our energy use and CO2 emissions The technology is already available to us to build or to retrofit completely carbon neutral homes. These homes would not require any form of heating and would be capable of generating their own electricity. The Government must set a target for all new buildings or building refurbishments to match this standard within 3-5 years. It could deploy the following policies to achieve this aim:

* A mandatory energy efficiency code for builders and designers;
* Financial incentives (subsidies or tax credits) so that these technologies become commercially attractive to consumers;
* All new build or refit works to public buildings (e.g., homes, schools and hospitals) should be required to use the most energy efficient technologies so as to provide a market and to showcase these technologies;
* Local councils (in addition to energy companies) should be assisted in rolling out programmes that would provide all households with a means to track their energy consumption and advice as to how to economise; and
* In the long term a CO2 tax could be levied on all buildings to penalise those who do not invest in energy efficiency technologies.

(ii) The National Grid loses more than 50% of the energy created, in heat or in transmission - Micro-generation provides massive energy savings because the heat emitted in the process of generating electricity can be used in local buildings or businesses. In addition relatively little of the electricity is lost in transmission through the grid. By positioning the generating facility within the local community, micro-generation also increases awareness amongst consumers of the energy cycle and therefore promotes sustainable, efficient and renewable forms of generation.

The Government must ensure that the regulatory framework is in place so that the electricity market is accessible and profitable to a whole range of local providers (individuals; communities; energy service providers and large commercial operators) who could supply directly to their own or to nearby communities.

(iii) Government should introduce a raft of tax credits and other incentives that reward consumers who decide to use low-carbon forms of transport such as trains or bio-diesel cars. The Government should recognise the public policy imperative for a radical approach to the massive inefficiencies in our current transport system. Government should not view this as an attack on motorists but rather as an opportunity to revitalise our moribund automobile market. It should be made commercially attractive for companies to compete to offer sustainable and low-carbon designs and uneconomic for consumers who choose to ignore these technologies. Further energy savings could also be derived from greater use of waterways, particularly for freight.

These measures would together put the UK on course to meet the Government's energy objectives without resorting to any form of new centralised capacity, including new nuclear power. However, in the long run we would still need to concentrate on continuing to develop and deploy further sources of CO2 free electricity (and heat) so as to phase out altogether our reliance upon oil or gas. The alternative technology that is currently available to us is a wide range of renewables: geothermal, solar hot water, solar photovoltaic (PV), biomass, heat pumps, wind, hydro, and tidal.

These technologies are already available, can all be sourced locally within the UK and have very little impact on the environment because in the main they simply harness the planet's natural forces and within their entire lifecycle none of them add to the volume of CO2 in the earth's atmosphere. However, critics highlight a number of factors that they suggest mean that renewables are not capable of replacing conventional energy sources and in particular the 12 gigawatts (GWs) that will be lost from existing nuclear power stations. They point to the fact that current methods of renewable energy are due to their intermittent and periodic nature expensive because they require back up energy sources for periods of low generation or for periods of peak demand. As such, further technological development is needed before renewables can be used as an efficient and reliable method of supplying our energy needs.

However, in-depth research and development in the UK has uncovered ways in which to alleviate many of the concerns about the cost and the reliability of renewables. The technology and systems planning is now in place for a viable renewables programme, as evidenced in the experience of other European countries: Germany already generates more energy from Wind and Solar power than our current nuclear capacity. Furthermore, although renewables are ideally suited to local or micro-generation, they can and already are used in the UK as a means of centralised generation for periods of peak usage. Admittedly, however, much investment is still needed in order for renewables to replace conventional heat and power generation in the UK. The Government must follow the example of those who countries who lead the race towards sustainability and promote investment in renewables technology in the following ways:

* Create a market for renewable forms of energy through financial and regulatory incentives to companies and individuals to invest in this technology;

* Listen to those business leaders in the UK who continue to appeal for the Government to give a clear indication of its commitment to these new technologies: for example James Smith, Chairman of Shell UK who stated recently 'We need EU governments to set clear targets to 2025 so that our businesses can have the confidence to make long-term investments in reducing emissions';

* Ensure that consumers are informed of the financial incentives and the benefits of renewables;

* Set in place the regulatory and planning regime that allows for renewables to be quickly and easily installed into all types of buildings.

* Create an accessible and profitable energy market for individuals; communities; energy service providers and large commercial operators who wish to develop and promote sustainable and renewable methods of generating energy.

This model would allow the UK to meet the CO2 targets that are necessary in order to prevent any further damage to our climate. It would also provide a sizeable amount of secure energy. As the technology is developed and as efficiency measures cut back our use of energy then we could also rapidly push back on oil, gas and coal powered generation.

The Government must not detract from the progress of such environmentally sound and economically efficient technologies. By subsidising nuclear energy or by including nuclear energy in any of the existing renewables/low carbon mechanisms it would be very difficult for a micro-generation market to expand. It would also send a clear signal to business that the Government is not committed to the long term replacement of fossil fuels by renewables.

Instead the Government should grasp the technological and manufacturing opportunities that climate change creates. If the Government continues along the lines suggested in the Review and does not invest and encourage investment in home grown renewable technology we will lose the technical capability to be a market leader and the opportunity will be gone for ever. The UK will face not only an unstable and changing climate but our future energy security, economic well-being and industrial development will all be seriously threatened.

The time has arrived to take difficult decisions and to implement ambitious policies that fulfil our energy needs and signal our progressive aspirations the rest of the world. Although tough in the short term such decisions are economically necessary for the long term future of the UK. Ultimately, a mix of renewable energy sources, efficient technology and careful use of resources are all that we need but we must start to harness them immediately, otherwise, it will be too late.

2. Introduction: Climate change and a shortage of energy supply

'As energy disaster looms…we have to stop rearranging deckchairs and do something effective, something that will actually alter our course dramatically, in time to make the crucial difference.'
Professor Walt Patterson

According to the mass of scientific opinion if we continue to burn fossil fuels at the current rate we will within 20 years have reached a situation in which we will have caused irreversible damage to our current climate. On a conservative view, the ice caps will melt, sea levels and temperatures will rise and huge areas of land mass will become uninhabitable for humans and wildlife. More extreme predictions forecast a slowing down of the Gulf Stream leading to extremely cold winters in the UK.

Quite apart from the damage that burning oil or gas causes to our climate, there is the very real threat that over the next ten years, the availability of both types of fuel will start to decrease. This is down to a number of factors including dwindling supply , increased instability in the nations from which we source these fuels and increasing demand from developing nations. It is likely to lead to soaring prices, a crisis in our economies and continued hostilities between nations for access to an ever more scarce resource. At the same time the UK's current nuclear capacity is dwindling (it is currently at 8% of our energy mix (20% of our electricity generation), is due to be retired. As set out in the quotation from Professor Walt Patterson (above) and repeated by a number of other experts in the field (for example a recent article by Jonathon Porritt, Chair of the SDC in the Guardian), it is necessary for the Government to set out a coherent, progressive and radical energy policy. Any such policy will set out immediate and longer term strategies that provide a sustainable supply of energy to the UK, whilst also allowing the UK to meet its CO2 emissions targets.

3. Short to medium term: Efficiency
In the UK per capita energy consumption has risen over the past two decades, with an overall increase of 9.37% since 1990 (DTI – UK Energy in Brief 2005).

One example which neatly illustrates how as a society we are failing to conserve our energy is the way in which we light our buildings in the UK. Every night, hundreds of buildings in the UK (for example shop-fronts, offices or stations) are fully lit when there are very few people actually benefiting from their use. The reason for this is that the market has failed to correctly apportion all of the costs associated with this resource. It is, therefore, economic as well as convenient to leave the lights on for the purposes of cleaning or advertising. The cost of retrofitting buildings with systems that automatically shut of when not in use is more expensive than leaving the lights on.

In order for this situation to change, the Government will need to moderate the way in which the market operates. For example, if the appropriate level of VAT relief were to be granted for efficient lighting systems then it would become a matter of economic necessity that companies and individuals ensure that they conserve this very important resource. In time, as it became accepted in the public psyche that energy efficiency is an important factor, a CO2 tax could also be levied to discourage the worst and most persistent offenders.

To date it would appear that the Government has chosen to largely ignore the fact that such regulation is necessary in order to address areas of market failure in relation to energy conservation. Instead the Government is concentrating its efforts on asking companies and individuals to voluntarily take responsibility for conserving energy. In a recent joint statement, the Energy minister and the DTI minister spelt out the need for an environmental contract which seemed to focus mainly on the responsibilities of companies and individuals as opposed to government for ensuring a sustainable future for the UK. Around the same time the EU Commission launched the "You Control Climate Change" campaign which set out 50 ways in which citizens can reduce their affect on the climate. It is interesting to contrast this approach to that of other Governments. The State of California, for example, through a package of financial incentives and regulatory obligations has ensured that business and individuals have become so efficient that energy use per capita has been flat for 30 years. The State government recently issued further plans to halve its rate of growth of electricity consumption by 2013 using the same brand of policies that has encouraged nearly 50% of the population to drive highly efficient hybrid petrol and electricity cars. Vermont has done even better, with efficiency measures that have already cut per capita energy use. Whilst individuals make everyday decisions which collectively can radically change the way in which companies operate, the greatest change is made where Governments push suppliers into a position where they must factor environmental externalities into their business plans (for example ASDA/Wal-Mart announced recently that it is pursuing a carbon neutral model, following a meeting with the Environment Minister). Market regulation is a notion which is already widely accepted in many areas of commerce and finance. For some time now markets, such as financial services, telecoms or transport, have been subject to strict regulation and continue to be monitored closely by officials at the Financial Services Authority or the Office of Fair Trading. Environmental costs, such as CO2 emissions or the protection of scarce resources are no different and the reality is that it is not individuals but Governments who have the power to ensure that this happens.

The Government must grasp the model of regulatory control and financial incentives to urgently address the following key areas of energy consumption in the UK.

3.1 Buildings
DTI statistics show that dwellings, account for around one-third of the energy (heat and power/electricity) use of the UK .
At present national and local government policy is focused on ensuring that regulations are enforced which provide for the stability and safety of buildings. Planners are also fixated upon not allowing for buildings to be constructed that would spoil our traditional landscape.

However, national and local initiatives to encourage greater energy efficiency and reduce CO2 emissions in construction, in terms of the refurbishment of existing stock or the construction of new stock, are merely voluntary schemes (e.g., the Government's new planning policy guidance on climate change, which is due out later this year).

Such voluntary regulation lacks sufficient political or financial support to bring about a radical change in attitude to buildings and construction. What is required is for energy efficiency measures (e.g., insulation, windows, heating systems) to be placed alongside safety and aesthetics at the top of the planning agenda. This should be imposed upon all developers and builders through an obligatory code based on the most ambitious of energy saving targets (e.g., the Energy Saving Trust's Energy Efficiency Best Practice Housing Programme'). Any such code must be strictly enforced and, as with other aspects of planning regulations, heavy fines would be imposed for non compliance.

The Government and Local Councils should also offer financial incentives to developers and individuals who are willing to make the financial investment needed to adopt new and sustainable methods of design when building or refurbishing their property. One way in which this could easily be achieved is to make it a requirement that any new development (residential/business) is constructed in such a way that it has zero environmental impact (providing of course that it meets minimum levels of design safety). In Germany there are now some 4,000 homes built to this standard .These buildings (known as Passivhaus) produce all of the heat required (which is the majority of energy consumed in most buildings) through the efficient capture of sunlight and the heat generated by the bodies of the people who live there. The buildings which are also efficiently insulated against energy loss are only around 7% more expensive to build than ordinary houses because they do not require heating systems.

Where public housing or buildings are involved, then the Government/Local councils are in a particularly strong position to require that these buildings meet such minimum levels of sustainability. In the southeast of England, where the Government aims to build thousands of new and affordable houses, the aim should be to make all of these houses cheap to operate and cheap to live in, along the lines of the Passivhaus standard.

It is important that policy is also directed towards retrofitting existing households with energy saving systems, in particular efficient insulation. New build housing accounts for between 1% and 1.5% of the housing stock, in each year so transforming the remaining 99% is essential in providing long term reductions in energy usage and CO2 emissions. The Chinese Government has already recognised this and recently announced that all public buildings in China are to be retrofitted with advanced energy saving technology.

As a first step, the Government could fit all homes with smart-metering, so that households can track their energy consumption. Local authorities should also ensure that all households are encouraged to undergo an audit of their energy usage, during which they could receive advice as to how to cut down their energy consumption. The best method by which to do this would be to require energy providers to pay for these to be installed. Companies could be allowed to recoup those costs gradually from consumers over a period of time and Government could even consider allowing companies to lock consumers into contracts for a period of time until those costs are recouped (a system not dissimilar to pay monthly mobile phones)
Overall, there must be a radical shift in the level of usage and awareness amongst developers and individuals of energy efficient designs and available technology.

3.2. Efficient localised energy generation
Our current energy system, based around the National Grid for electricity, is extremely inefficient: Only around 20% of the primary energy input (coal or gas) is eventually used since large amounts are wasted as heat and/or in transmission.
However, there is already in use an alternative to this wasteful and inefficient system in the form of localised micro-generation. Currently, the cheapest method of this form of power is through combined heat and power "co-generation" gas boilers (CHPs). Groups such as the Energy Saving Trust are also promoting the use of small wind turbines or solar panels. All of these technologies can be retrofitted to buildings with relative ease together with a fuel cell which allows for the energy that is generated during times of low usage to be stored for periods of peak usage.

Because micro-generation situates the generator in the location where the energy is being used in the same building, on the same street or in the same town then less energy is wasted in the course of transmission. In the case of CHP boilers there is the added benefit of being able to use the heat which is given off in the production of the electricity to supply nearby buildings. CHPs are therefore up to 80% more efficient than conventional modes of heat and CO2 emissions from CHPs are on average 50 per cent less than that of large-scale gas-fired plants.

Micro-generation also has major benefits in terms of introducing energy generation as an issue in the local community and therefore encouraging consumers to take a greater interest in energy conservation. For example in Woking, the local council decided to invest in order to become a carbon neutral community. As a consequence buildings are now extensively fitted with low-carbon technologies and are powered by energy generated by community CHP generators, fuel cells and renewables, whilst households are also provided with financial incentives to fit renewables: council officials believe that there has been around a 40% increase in energy usage efficiency and other local areas such as Merton believe that there is nor reason why the Woking model cannot be adopted in their locality. Mayor of London Ken Livingstone has already responded to the DTI's Energy Review by stating that he will oppose any moves towards more centralised nuclear generation. Instead his London Plan Review will require planners and developers to connect all new developments in London to local CHP or renewable energy supplies .

However, the centralised and highly regulated nature of the market means that the Government cannot rely upon local authorities, who operate within a limited geographic, regulatory and budgetary remit, to implement measures aimed at proliferating micro-generating capacity. In the 1970s the Government cut transported air pollution (Sulphur Dioxide, Nitrogen Oxide and Mercury) by

forcing Companies and individuals to replace or convert their coal fired appliances to use North Sea gas. A similarly co-ordinated strategy is now required by the Government to ensure that the UK moves towards an optimum system for the generation and transmission of heat and power.

Principally, the power market must be regulated in such a way that it is open and competitive: Existing pricing mechanisms, which are set by the Government and the current method of organisation of the national grid, represent significant barriers to entry for private companies who wish to promote and supply micro-generating capacity to local businesses or communities. The grid is necessary in order to connect users to centralised and often remote power stations. As such, even under a sustainable energy model there will continue to be a need for a grid in order to connect centres of power generation which are in many cases isolated from the point of use, e.g., off-shore wind farms or tidal farms. However, as centralised oil, coal and gas station are phased out then the grid will not need to be maintained to the same scale or standard.

Furthermore, the Government must ensure that planning and permitting regulations do not continue to act as additional barriers to the quick and inexpensive introduction of small scale generating capacity by businesses or communities.

Even once the regulatory regime is in place it will of course take time for local businesses and communities to universally adopt localised generation. In order to stimulate immediate investment, every new public development should be built with its own generating capacity. Commercial developments and refits should be favoured by the planning regime where they include plans to include on site (CHPs or renewables) generating capacity (see for example the plans for the SnOasis project in Suffolk).
Together these initiatives would create a lucrative market for micro-generation systems, replacing the wasteful and inefficient supply of electricity which is generated centrally and distributed via the National Grid. The National Grid would become purely a secondary market for communities or companies who need back up energy or who wish to sell off their surplus power. However, Local authorities would also continue to work (see for example Woking and Merton) with energy companies to ensure sufficient regional micro-generation capacity, even for times of peak power use. As large scale (nuclear and fossil fuel) plants were decommissioned the structure and network would be in place for regional legislators and energy providers to replace all centralised power with localised and regional renewables and CHP capacity.

3.3 Transport

Transport is another key area where urgent political intervention is required in order to radically change consumer practice. Transport accounts for around 30% of the UK's CO2 emissions. Nearly half of that is accounted for by passenger road travel . The significant increase in the volume of travel has continuously negated any advances in the efficiency of our different forms of transport. Similarly, whilst individuals can be encouraged to economise on travel, use public forms of transport or use more efficient private means of travel (e.g., motorcycles) if we wish to sustain even current levels of transport use then we will need to find a replacement for fossil fuels.

Due to the specialised conditions needed for nuclear generation, nuclear power can only impact on transport through another means (e.g, through the production of electricity or hydrogen). Hydrogen can be used to provide heat and to power a fuel cell. A fuel cell is a kind of gas battery that combines hydrogen and oxygen to produce electricity, with water and heat as its by-product. As long as fuel is supplied, the fuel cell will continue to generate power. Since the conversion of the fuel to energy takes place via an electrochemical process, not combustion, the process is clean, quiet and two to three times more efficient than burning fossil fuels.

Much of the research into hydrogen fuel systems has been promoted by the automobile industry which hopes in time to develop a fuel cell that is small enough, cheap enough and reliable enough to be incorporated into a car in combination with an electric motor. A hydrogen network could also be used to provide heat and electricity to our homes.

In order for fuel cells to be able to replace conventional fuels then we would need to ensure a sufficient supply of hydrogen and a network to distribute it. Hydrogen can be transported using the same sort of system as natural gas. However, the pipes which are needed are about 50% wider than those which are currently used for natural gas. Consequently massive investment would be required for an entirely new infrastructure and the resource implications make it, for now at least, an unattractive option.

An even greater issue is the fact that essentially hydrogen is simply a method of storing and delivering energy in a clean and efficient manner. That is because a significant amount of energy is required simply in order to produce hydrogen. The only CO2 free method is through the electrolysis of water which demands a significant amount of electricity. Other methods, such as reacting natural gas with steam and capturing and burying the carbon it contains or passing steam and oxygen through pulverised coal (and catching the carbon), are cheaper but still produce moderate CO2 emissions.

The disruption and cost which would be involved in developing the required infrastructure and then the technology for the new vehicles means that whilst hydrogen must remain a long term possibility it cannot currently provide a solution to our energy hungry transport system.

In the meantime it would appear prudent to use the most efficient options that are left open to us. The most obvious of these would appear to be bio-fuels. Bio-fuels are mainly derived from recently living organisms (in particular high energy storing plants, such as corn or rapeseed). Burning bio-fuels releases CO2 into the atmosphere but there is no nett release of CO2 because, unlike Fossil fuels which contain carbon trapped for millions of years, biomass is made up of plants which recently captured the carbon form the atmosphere. . Bio-fuels are already widely used around the world. Bio-diesel (a processed bio-fuel), is capable of being used to operate conventional diesel engines, without modification and is in extensive use in parts of Africa and South America. In the USA, Chevron recently announced that it had formed a bio-fuels business unit to advance technology and pursue commercial opportunities related to the production and distribution of ethanol and bio-diesel in the US. There are currently several small organisations who offer bio-diesel in the UK and BP has announced a joint venture with DuPont to develop and produce an advanced type of bio-fuel, bio-butanol, which, due to the processes it is subjected to, can be used in a wide range of conventional engines.

Bio-diesel can be produced by three methods: ethanol fermentation from plants, esterification of vegetable oil and Fischer Tropsch synthesis . It has the benefit of creating much lower CO2 emissions than fossil fuels and because it can be made out of plant material it would remove much of the UK's reliance upon oil. A further benefit would be the creation of a highly integrated and localised bio-diesel production industry in the agricultural sector. On the East Coast of Scotland, for example, Terra Eco Systems is supplying sewage sludge, from the City of Edinburgh, to local farmers as organic fertiliser for growing rapeseed, wheat and barley that the company will then buy and process into bio-fuel. Research is also being conducted by several groups (including a consortia at the University of East Anglia) to develop a wholly sustainable model for farming sufficient amounts of the right type of plants in the UK.

However, in order for this system to be commercially viable it is necessary for manufacturers of cars, which have the largest share of the transport market, to be presented with incentives to promote and produce bio-fuel compatible engines over their conventional petrol equivalents. Consumers are attracted to petrol engines because in terms of driveability and comfort they are preferable to conventional diesel engines. Current patterns of consumption will only change, therefore, if there were to be a massive crisis in the supply of petrol.

However, it is not in the interests of consumers, car companies or the Government for us to reach this crisis point. Instead the Government should take the same type of decisive action that it took in the 1980s when it was discovered that the lead in petroleum was a serious health risk. It should introduce financial incentives designed to price petroleum based cars out of the market and replace it with a market for bio-diesel or other low-carbon technologies (e.g., hybrid petrol-electric cars). Excise duty could be increased for the most inefficient and polluting cars whilst low-carbon vehicles would attract no duty at all.

The Government should start by implementing a procurement policy under which all forms of public transport and their own fleet of vehicles are replaced by bio-fuel or other low-carbon alternatives (e.g., hybrid vehicles). The Government should not underestimate the powerful effect that the Prime Minister and cabinet could have if they were to be seen being driven in a bio-fuel or hybrid car. It would send a clear signal that the UK is open to a new automobile market, one in which it may even be possible for entrepreneurial UK based companies to compete.

Further energy savings could also be derived from greater use of rail and water. Whilst the rail infrastructure may not easily accommodate much greater volume our major rivers, and the remaining canal system, could. For example, the River Thames is currently used for the carriage of over 3M tonnes of aggregates into London. The aggregate companies state that this volume could not be carried by road or rail, either in terms of economics or logistics. However, the utilisation of the river for ship movements remains relatively small.

4. Long term: Technology

Greater care in the way in which we use our energy is only a short to medium term solution. It should delay an energy crisis and allow us to continue to meet our modest CO2 emissions targets. However, without more radical and entrepreneurial action further energy shortages would appear inevitable: the growth of the global population and the further development of countries such as China and India are likely to mean a doubling in car use alone over the next 10 years.

The UK must aim to catch up with the leading sustainable EU states (Denmark, Sweden, Holland and Germany) over the next 15 to 20 years and guarantee that we have a secure and sustainable energy future. The UK (and Europe) is in the privileged position, because of our wealth and technological advancement, to take the global lead in reducing emissions and returning the planet to a safe and sustainable equilibrium.

We must also grasp the technological and manufacturing opportunities that climate change creates. If we do not invest and encourage investment in home grown renewable technology we will lose our opportunity. Much of the opposition in the US to Federal climate change inaction is driven by industries which have identified commercial opportunities for new technology and, hence, for new avenues of trade.

So what are the technologies and options that are available to us over the longer term?

4.1. Renewable forms of energy generation
One source of plentiful and affordable CO2 free electricity (and heat) is in the form of a wide range of renewables: solar photovoltaics (PV), biomass, wind, hydro, heat pumps, geothermal, solar hot water, and tidal. Wind , Solar PV and Biomass are technologies that are already widely available and in use around the UK. Renewables are hugely beneficial because they are non-polluting and are powered by the earth's natural forces so that they can be used continuously without damaging the climate. They are also a secure source of energy because they are located within every locality.

Critics highlight a number of factors which they suggest mean that renewables are not yet capable of replacing conventional energy sources and in particular the 25 GWs that will be lost as existing nuclear power stations are decommissioned over the next ten to fifteen years. They point to the fact that current methods of renewable energy are expensive due to their intermittent and periodic nature and will require a great deal more technological development before they can be used as an efficient method of major energy generation.

However, the research which has already been undertaken in the UK and the results suggest that such reservations have been hugely overstated. First, new renewables technologies are rapidly emerging. For example, a UK engineering firm has recently brought to market a wind generator called 'Quiet Revolution'. The turbine operates on a vertical axis and so does not take up as much space as conventional horizontal axis turbines. It also has a triple helix fan and so is quiet and efficient at capturing wind from any direction. The design is, therefore, capable of being easily deployed in urban areas.

Secondly, models have been developed which demonstrate how the periodic nature of renewables can be accommodated into our system (for example, a recent report produced by the UK Energy Research Centre). It would appear from these studies that the intermittent or periodic nature of renewables need not present a significant obstacle, either in cost or in reliability terms, to the development of renewables as a replacement to existing power output for the following reasons:

* A wide range of renewables can be used at different times in the same given area;

* It is possible to calculate and plan with relative ease the output of fossil fuel plant that will be required in order to provide any additional capacity that is required. As such, the introduction of significant levels of intermittent renewable energy would not lead to reduced systems reliability;

* Although extra capacity would be needed to keep supplies secure, such capacity will be modest and a small part of the total cost of renewables (especially if it were in the form of localised CHP plants);

It would be possible over time to provide our entire stand by (peak) capacity through renewables. This could be done by using excess wind, solar or tidal power to pump water into hydro turbine reservoirs (e.g., the Dinorwig plant in North Wales which uses a system whereby water is pumped into a high reservoir and then released to a lower reservoir to generate electricity at up to 1320 MW within just 12 seconds). There is also the possibility of storing the excess power in batteries or hydrogen fuel cells.
Indeed, current trends in the uptake of renewables across Europe support the notion that they could provide for a dominant amount of the UK's energy needs at an affordable cost:

Spain and Germany's ventures into wind power alone added as much power capacity in 2004 as the world's nuclear industry will add from 2000 to 2010. Industry projections indicate that by 2010, renewable and low-carbon sources will offer 177 times as much added capacity as nuclear ;

Germany has similar levels of sunshine and less wind than the UK but already exceeds our 25 GWs per year of nuclear production with wind generation and, within three years, will have a similar level of PV capacity as well ;

A recent survey by the British Wind Energy Association found that wind turbines are set to generate far more electricity than previously thought (almost half of the Government's 10 per cent renewable energy target by 2010). This will produce almost five per

cent of the UK's electricity supply and displace up to 13 million tons of CO2 emissions. The electricity generated will be sufficient to power the domestic population of London and Glasgow combined; Many US States and even the US Federal Government it appears have also taken on board the importance of renewables and are encouraging large scale renewable energy installations.

The current uptake in the UK of renewables is in large part due to the Government's commendable policy of offering subsidies to consumers who use these resources. However, despite the increase in their use, market penetration is still insufficient and sporadic. As can be seen from the experience of other European counties, this is not because of a lack of available technology (see also article by the Oxford research Group), but because of the current organisation of the market. Companies are reluctant to invest vast amounts in new technologies until they perceive that there will be demand.

One possible mechanism by which such demand could be stimulated was proposed in a recent study into the feasibility of Biomass by the Department for Environment Food and Rural Affairs. It recommended a single capital grant of 40% of capital expenditure on exploiting biomass in the form of biomass-fuelled power plants, on-site heating boilers and the heat element of CHPs.
A further driver which could be used by the Government is to open up its own estate solely to providers of renewables and micro-generated energy. The Government's estate contains over 50,000 buildings. This would create a sizeable market and so significant financial incentives for companies and investors to develop and market systems involving renewables technology.
In addition to stimulating demand through such substantial financial incentives, Government must, also urgently tackle the supply side dynamics of the energy market. Energy suppliers and providers (BP, Shell, EDF etc.) have historically invested hugely in the infrastructure around centralised forms of fossil fuel and nuclear generation. This has been done with the financial and regulatory backing of government and these technologies are now widespread and relatively cheap. As such, until the price of the fossil fuels or uranium which feeds them rises to meteoric levels then a mass market providing consumers with affordable access to renewable energy or infrastructure cannot quickly emerge. In order for that to change the Government must ensure that the environmental and security benefits associated with renewables are given due weight in the market. This may only partially redress the cost differential but more importantly it will give a clear signal to investors that there will be a return on their investment over the next 5-10 years if they aggressively develop and market renewables.

Finally, there is also a need to remove a number of regulatory barriers. The major regulatory barrier to the development of renewables energy has been planning regulations. Wind turbines in particular have traditionally been blocked as a means of wide spread generation because they are unpopular with local residents and heritage groups who see them as a blot on the landscape. A biomass power plant was recently refused planning permission in Devon on grounds of landscape change.
Recently the Government appears to have recognised the need to address this. The Local Government and Communities Secretary, Ruth Kelly, recently promised that legislation would be enacted to remove the necessity for planning consents for all forms of renewables. If the Government needs any additional arguments to carry this through then it can rely upon a recent NOP survey commissioned by the DTI. The report found, that 81% of the general public are in favour of wind power and just over three-fifths would be happy to live within 5km of a wind power development. A practical illustration of this is the Westmill wind farm in Oxfordshire which is planned to have five turbines amounting to 6.5 megawatts of electricity. The project has proved so popular that some of its investors are being turned down and reimbursed: it only needed £3.7 of the £4million pledged by 2127 people.

4.2. Diversifying conventional forms of generation – Nuclear and "clean coal"
4.2.1 Nuclear
A new generation of nuclear power stations could plausibly be built in the UK within the next 10-15 years. This new capacity could provide higher levels of safety, although the technology involved is currently still being fully tested (e.g., the European Pressurised Reactor (EPR) at Olkiluoto). The risks associated with transporting, reacting and disposing of radioactive material remain high.
Given the risks, as well as the fact that it will be around 10 years before the plants are built and running sufficiently effectively to make a return on the investment put in, there remains little enthusiasm amongst the private sector for investment in nuclear project. Our existing nuclear plants failed to survive as a private enterprise and have subsequently been an extremely expensive project for the public purse. Financial analysts remaining similarly sceptical about the proposed new generation of nuclear plants claiming that without large government subsidies it will fail to attract private investment.

The human and environmental risks and costs associated with mining radioactive materials will also become increasingly difficult to externalise from the equation. If we are to be taken seriously as a modern and progressive economy and nation then we cannot ignore the damage caused by the radioactive tailings that remain from uranium mining projects at thousands of locations across Europe and the rest of the world. Even the World Nuclear Association has admitted that although it has imposed more rigorous safety measures, there is a serious risk that the greater demand for uranium across the globe is likely to lead to more contamination.
In order, therefore, to encourage private investors to take on the risk of nuclear power then the Government would need to offer massive subsidies to cover capital, operating and decommissioning risks. It is difficult to see how this would exclude a guarantee of the

long-term stability of the price of nuclear generated power. This would eat into the current premium-price, market-enabling mechanism provided to low-carbon technologies by the Non-Fossil Fuel Obligation (created by the Electricity Act of 1988). As such, almost any growth in micro-generation and renewables is certain to be destroyed: BP and Shell have suggested that their continued investment in renewables is threatened by the Government's pro nuclear stance because they are unwilling to risk further research and development on products for which a future market may not exist.

It is also questionable whether nuclear subsidies would comply with European Union regulations aimed at maintaining a competitive energy market: the European Pressurised Reactor (EPR) at Olkiluoto in Finland, financed at extremely low rates of interest by French and German state-owned organisations is currently being investigated by the European Commission.

Finally, uncertainties remain about the long term ability of nuclear power to reduce CO2 emissions. Research has shown that the known global reserves of high-grade uranium ore, which we require to fuel nuclear power generation, will, at current levels of consumption, last until about 2034. After that date, recoverable uranium ores would be of such a low-grade that more that we would need to expend a large amount of energy simply to extract and then process the ore so that it can be used as uranium fuel. Eventually (perhaps as early as 2070) the grade of uranium ore being used could be so low that nuclear power will become a net energy user and carbon dioxide emissions from nuclear power could be as high as those from gas-fired power stations. Alternatives to uranium, such as Plutonium, are not yet fully tested in commercial reactors, so doubts remain as to the efficiency of this process. Furthermore, the proliferation of plutonium would cause serious security risks since it is the same radioactive substance that is used in nuclear weaponry .

4.2. 2 "Clean coal"
A second potential form of sustainable energy generation by conventional means is the use of "clean coal" power stations. 'Clean coal' involves the process of removing all, or at least significant amounts, of CO2 from the flue gases of coal burners and then burying it under ground or pooling it on the sea bed. It is also possible to treat the coal before it is burned, although an enormous and unsustainable amount of energy is used in the process.

The attraction of 'clean coal' generation is clear. Coal is in plentiful supply in the UK and can be extracted at limited expense. Furthermore, the technology, although expensive, is already available to remove large amounts of CO2 from flue gases. These could in time be fitted to the majority of old and new coal burners and efficiently remove the majority of the CO2 that is emitted. Greater uncertainties exist, however, in relation to the process of securely storing the CO2 that is captured. Norway recently began operating a pilot facility to store carbon dioxide separated from natural gas in a deep saline reservoir under the North Sea. However, it is not yet known whether there will be slow leakage from such saline aquifers which would if it occurred simply defer the problems associated with CO2 dispersal in the atmosphere and acidification of the sea.

Doubts also remain as to the feasibility of storing the CO2 in former oil or gas reservoirs. Limestone often caps gas and oil reservoirs and is sufficiently dense and flexible to produce impermeable caps. However, CO2 in aqueous solution reacts with limestone (calcium carbonate) to form calcium bicarbonate which is water soluble. Recent research in Houston, the Frio Brine Pilot Experiment, demonstrated that this process can cause serious erosion and cracking of the cap material . This could again lead to an early catastrophic release of CO2.

In the UK the view has been that ocean disposal by injection cannot be considered to be a practical policy option unless the technology has been demonstrated and the environmental impacts researched . Development and research into "clean coal" power stations, through the use of carbon capture and sequestration is ongoing. However, it is still a long way from being a sustainable method of CO2 free energy generation. There is also a serious issue associated with the release of harmful transported air pollutants, in particular Sulphur dioxide, nitrogen oxide and mercury.

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