ENERGY WHITE PAPER

Keeping the lights on in the cheapest, cleanest way

As the electricity supply industry changes from burning fossil fuels to new low carbon generation, there is a great opportunity to utilize combined heat and power, which is the cleanest, most efficient form of energy generation. The White Paper recommends investment in renewable energy, mainly large wind farms, nuclear power and fossil fuels with carbon capture and storage. It does not claim that its proposals will ensure that electricity will be generated efficiently, but only that it will be cheaper and cleaner. Much of the electricity industry is wasteful and inefficient, but the most polluting capacity will be phased out during the coming decade. The White Paper states that in past decades electricity has been inexpensive, but we have now used up much of our cheap, irreplaceable fossil fuels and will have to buy more on the global markets. It has also left a legacy for the future of £billions to cover the costs of nuclear waste disposal and an untold sum for the future costs of climate change.

The electricity industry has achieved good reliability and freedom from blackouts and the White Paper makes useful proposals for ensuring that this continues in the future. There is however, little support for distributed generation, although the White Paper accepts that combined heat and power (CHP) is more efficient and further consideration is being given to this. Our present electricity generating system is only about 35% to 40% efficient because the heat is not utilized and there are losses during transmission from central power stations. For comparison, combined heat and power systems achieve in the region of 85% efficiency, with fuel cells generating a high ratio of valuable electricity.

Fair terms for competitors?

The White Paper aims to provide a liquid market for investors, which will enable both existing energy companies and new entrants to have access to the investment they require. However, Government policies discriminate against fuel cell combined heat and power, which is the most efficient technology, as systems over 2kW do not qualify for Feed in Tariffs (FITs). Fuel cells are already providing electricity, heat and cooling in hospitals, schools, supermarkets, office buildings and at wastewater treatment facilities, but their wider implementation has been held back by competition from cheap fossil fuels which are not covering their external costs and have an established infrastructure. Fuel cells could become competitive if they received the same support as other technologies while they are being fully developed and economies of scale achieved. The new Green Deal should encourage solutions which save both electricity and heat.

Major changes to the electricity grid

During the coming decade, about a quarter of the installed electricity generating plant, in the region of 20GW, will have to be replaced and the electricity system will contain more generation from intermittent renewables, as well as inflexible base load generation with nuclear power. The UK has a legal obligation to obtain 15% of all our energy from renewable sources by 2020 and the Climate Change Committee has advised that the electricity generating sector should be largely decarbonized by the 2030s. Fuel cells can be the most efficient and cost effective means of reducing greenhouse gases and commercial production is already starting in the USA, South Korea and Germany.

Load balancing and storage.

Energy storage will help to smooth out the supply from intermittent renewables. This will allow electricity from the sun to be used for lighting homes in the evening and for large quantities of energy from wind farms to be stored for use in CHP systems or to power transport. According to a report by the Bow Group, local hydrogen storage will have the following benefits:

- improved efficiency as supply matches demand
- the need for fossil fuel back-up is removed
- lower carbon emissions
- less investment in infrastructure costs
- reduced stress to the system as ramping up and down is minimized
- grid stability and continued freedom from blackouts
- community, business and individual self-sufficiency.

However, further technical improvements and cost reductions are necessary to make wind power with hydrogen storage competitive with diesel generators. It is recommended that there should be a renewable energy storage incentive (RESI) to build up a distributed renewable system which generates, stores and utilizes green energy at the point of use.

OFGEM estimated that up to £450 million per annum could be required to balance the electricity load from intermittent renewable energy, including the use of stand by fossil fuel power stations. Fuel cells will not incur these additional costs as they can be easily ramped up and down and they can operate 24/7. Electric vehicles, both battery and fuel cell powered, will provide an important means of storing electricity at times of low demand.

Energy Security

Energy security is equally important. The Government is arranging for an assessment to be made every year to ensure that sufficient generating capacity is installed to meet future requirements and avoid blackouts at times of peak demand. Fuel cells could contribute to energy security as they can be powered by a variety of fuels including: biofuels from waste; hydrogen obtained via the electrolysis of water when there is surplus wind, solar or marine energy; off peak nuclear power; and fossil fuels with carbon capture and storage. Highly efficient fuel cell CHP systems will help to conserve depleting resources of natural gas.

An important source of renewable energy to power fuel cells is the tremendous energy store locked up in existing landfill sites. The clearing, reclamation and restoration of the older sites could deliver massive benefits by recovering and recycling metals and converting all the plastics and other organic material into useful end products. This would be a high value energy exporting, profit making cleanup programme, providing millions of tons of usable energy on our doorsteps. Converting this energy has massive benefits, by producing green energy locally, reducing traffic to traditional generators, restoring and reclaiming land, removing potential pollutants, creating employment and avoiding investment in polluting technologies. Fuel cells can be powered by biogas obtained from the organic waste.

Renewable methane may also in future be obtained from sustainable sources, by extracting $C0_2$ from the atmosphere, alongside large scale concentrating solar power or wind farms, which could produce hydrogen when electricity demand is low. This process would help to stabilize $C0_2$ in the atmosphere and would provide sustainable fuel for efficient high temperature fuel cell CHP systems. The fuel cells would continue to utilize the existing natural gas infrastructure, thereby involving less investment in the new hydrogen infrastructure.

Innovative SMEs need funding to develop and bring new products to market. At a recent public meeting in London, Prof John Loughhead, Executive Director of the UK Energy Research Council (UKERC) likened fuel cells to electric light technology, which took decades to reach the market due to the strong lobbies for existing gas lighting. “Waves of electric light manufacturers

were bankrupted until the gas light companies could no longer compete and people became accustomed to electricity", he said. In the age of globalization it is even more difficult, as potentially helpful bankers have to refer decisions to central computers which still do not take into account external costs. At a recent public meeting the representative from the Energy Technology Institute, which receives £500m of taxpayers' money, dismissed fuel cells as being too expensive. This is misleading, as it applies to any technology under development which is starting low volume production. In fact the main objective of scientists and engineers is to reduce costs by developing materials and techniques to improve the logistics for volume production.

The public wants a choice of clean, efficient technologies, rather than having decisions made for them by central government and global corporations. Fuel cells could be introduced alongside innovative micro wind energy technologies which operate in variable wind speeds in urban areas, as well as photovoltaic systems. Businesses and communities could use their waste to generate electricity on site. Once small scale production is underway, manufacturing could increase at exponential rates. The Government's proposals for micro-generators are of little assistance to innovative SMEs, as they are directed at helping system installers and fail to address the lack of finance for product development.

Future energy

In the future, electricity and heat will increasingly be generated on site by highly efficient fuel cells. There will not be separate fuel sources for electricity, heat and transport, but more electricity and heat will be generated on site, with electric vehicles acting as load levellers. For instance, in a future Europe where vehicles are powered by electricity, if 25% of drivers used their electric vehicles as power plants to sell energy back to the inter-grid, all the major power plants in Europe could be eliminated. The Government's Renewables Roadmap generally supports the global energy industries, which do not want to make substantial changes from the present inefficient central generation of electricity. This arrangement also gives them a separate market for heat.

The age of dirty and inefficient combustion will be over, when electrochemical energy conversion enables clean, efficient production of electricity and heat. Energy will be stored as hydrogen, just as digital is now the universal data storage. Many scientists and engineers realize that, in the words of Jeremy Rifkin, the same design principles and smart technologies that created the internet and the vast distributed global communications networks are beginning to be used to reconfigure the world's power grids. This will mean that people can produce renewable energy and share it, just as they now produce and share information, creating a new decentralized form of renewable energy use. Combined heat and power generation, alongside efficient renewable technologies, will enable businesses, communities and individuals to ensure their own future security of supply. This will enable them to choose the cleanest energy, which will also be the cheapest, not just for them, but for future generations.

Jean Aldous,
Fuel Cell Power,
July 2011

Appendices: I Government Policies
II Related Technologies
III Global Warming Gases

APPENDIX I

Government policies

Policies will encourage the introduction of renewable electricity and heat but will do little to improve the efficiency of electricity generation and distribution. The **EU Emissions Trading Scheme (EU ETS)** is expected to make substantial reductions in $C0_2$ emissions by the major electricity generators over the coming decade. **Climate Change Agreements (CCA)** made between the Government and the larger users of electricity will also have an impact. **The Carbon Reduction Commitment (CRC)** obliges larger public and private organizations not covered by EU ETS or CCA to reduce their $C0_2$ emissions. Originally funds raised under the CRC were to be redistributed to participants in the scheme, giving more back to those with the greatest efficiency gains. It was proposed by the Committee on Climate Change (CCC) that part of the funds should provide up-front capital for non -profit organizations to invest in energy saving and renewable technologies. However, the Government has now decided to claw the funds back.

The White Paper proposes to change **Feed in Tariffs (FITs)**, so that instead of paying a premium to suppliers of low carbon electricity, there will be a contract for difference (FIT CfD), which will encourage the efficient use of renewables. When the price of electricity is below that agreed by the generators then suppliers of renewable energy will be paid the difference and when it is higher they will make a payment back to the user. FITs apply to renewable energy technologies up to 5 megawatts, but CHP systems only qualify if they are very small, under 2 kW. This will discourage communities, businesses and individuals from purchasing fuel cells, as other less efficient competitors will be subsidized by consumers. It is perhaps understandable that DECC, which is allocating half its budget this year to cleaning up after the nuclear industry, is reluctant to support larger low carbon projects, but they should not exclude low carbon technologies which have received no funding. If nuclear power provides base load electricity, this is itself a form of subsidy and the Government cap on the public liability of nuclear power is another form of subsidy. There could be a percentage of the public money allocated to each technology.

The **Carbon Price Floor (CPL)** and the **Emissions Performance Standard (EPS)** will ensure that the polluter pays and will make it easier for all suppliers of clean energy to compete. The EPS will set an annual limit to C02 emissions and will ensure that any future coal fired stations will employ carbon capture and storage (CCS).

Further work will be undertaken on the role of CHP, which could be entitled to 100% capital allowances, exemptions from business rates and Renewable Obligation Certificates for CHP powered by renewable energy. On the other hand, CHP plants may no longer be able to claim partial exemption from the **Climate Change Levy (CCL).**

The **Renewable Heat Incentive (RHI)** encourages the use of heat pumps, which can be powered by electricity from renewable sources. However, they will add to the electrical load on the grid at times of peak winter demand, which could increase the need for fossil fuel back up. Fuel cells would complement heat pumps, as they can be easily ramped up and down to provide electricity to power the heat pumps, as well as contributing additional heat at times of peak demand. The RHI also encourages the burning of biomass, which might be more cleanly and efficiently used in CHP units to provide electricity, which is a higher value fuel, as well as heat. Gasifiers or

anaerobic digesters can be used to obtain biogas to power fuel cells from agricultural, forestry or municipal waste.

A useful policy which will help to balance the electrical load when more energy is obtained from intermittent wind and solar sources is **Demand Side Response (DSR).** The White Paper recognizes that reducing demand for electricity will lower carbon emissions and is likely to be more cost-effective than building additional generating capacity. It is also important that users are aware that there are higher costs associated with electricity generated at times of peak demand, so smart meters will be introduced in every home to enable customers to minimize electricity use at such times. Smart Meters will have an important role, but DSR does imply that costs will increase at times when people most want to use electricity. On the other hand, the storage of electricity as hydrogen would enable people to use fuel cell generated electricity at the time when it is needed. Fuel cells powered by biofuels from waste can also be easily ramped up and down to provide electricity at the time when it is needed.

The **Green Deal** will help to ensure that the heat loss from buildings is substantially reduced. Fuel cell combined heat and power (CHP) systems would enable highly efficient electricity generation, as well as heat production that matches the requirements of future well insulated buildings. We are calling upon the Government to ensure that the Green Deal should give priority to measures which save both electricity and heat. The **Green Investment Bank** will provide investment in low carbon technologies, but it is important to ensure that the most efficient technologies are developed for future production.

The Treasury has allocated £1 billion for four C**arbon Capture and Storage (CCS**) projects for coal and gas fired stations, which will be required to provide back up at times of peak electricity demand, or when the supply from intermittent renewable sources is low. Over the past decades scientists have developed alternatives to CCS which could be more efficient and safer processes than digging up fossil fuels and then burying the $C0_2$. Methods for extracting carbon dioxide from the atmosphere and synthesizing it with renewable hydrogen to form renewable gas or liquid fuels would give a value to atmospheric carbon which is now an unwanted pollutant.

Policies re Fuel Cells

In the past, the Government backed the development of two types of fuel cells, the Proton Exchange Membrane (PEM) and the Solid Oxide Fuel Cell (SOFC), both of which have great potential, but have required lengthy materials development. The R & D of larger Molten Carbonate Fuel Cells (MCFC) and Phosphoric Acid Fuel Cells (PAFC) have not been supported. For the Apollo Project in the 1960s NASA put $100 million into alkaline fuel cells which had been developed in the UK by F T Bacon. Since the 1950s this cheaper technology has not been supported by the UK Government. Alkaline fuel cells have the potential to be the cheapest means of generating electricity as well as providing heat for buildings and a clean fuel for future transport.

APPENDIX II

Related technologies

Fuel cells will complement renewable energy technologies. Hydrogen fuel cell systems will smooth out the electrical load, on both a small and large scale, when there is plentiful renewable energy from solar, wind and marine sources. They will complement the use of heat pumps, providing electricity and heat at times of peak winter demand. Fuel cells powered by waste will generate cheap, efficient on site electricity and provide back up back up when required for renewables. The use of fuel cells will facilitate the introduction of small scale distributed energy technologies. Engineers are developing micro wind energy collectors which operate in the fluctuating wind conditions in urban areas. Developers of PV have been set back by the reductions in the FITs payable for larger schemes, which could have enabled them to achieve economies of scale. This change sends the wrong signal to potential investors. The Renewables Road Map does not recognize solar PV as one of the leading contenders for future energy supply, although it makes it clear that the Government expects larger scale PV projects to be cost-competitive with offshore wind and dedicated biomass generators.

Fuel cells will increasingly be used to power heavier duty electric vehicles which require longer range and most of the global automotive industry is aiming to start production of fuel cell cars in 2015. Several British SMEs have been unable to get R & D funding for efficient, lightweight electric vehicles, although substantial funds are being allocated to less efficient electric cars produced by the global automotive industry. Smaller scale, local production, aimed to start with niche markets, is possible with carbon composite bodywork, which does not require the extensive tooling required for the manufacture of steel bodied cars.

APPENDIX III

Global warming gases

The measures the Government have in place to reduce global warming gases are quite selective. For instance, they do not cover the embedded emissions imported in products which were once manufactured in Britain, nor the greater impact of global warming gases caused by aviation at higher altitudes, nor the feedbacks which can equal anthropogenic emissions. Carbon Capture and Storage (CCS) does not remove all the $C0_2$ that is generated by fossil fuels and there is insufficient safe storage space to ensure that it remains in storage for thousands of years. The capture of $C0_2$ from the atmosphere and its synthesis with renewable hydrogen could be a less risky technology. If it were necessary to avoid dangerous climate change, some of the renewable liquid fuels could be put back into empty oil wells in order to bring atmospheric $C0_2$ concentrations back to a safer level.

The Government only takes $C0_2$ into account, although methane is 22 times more potent in the short term. The International Energy Agency (IEA) says that due to the high global warming potency of methane and its short atmospheric lifetime, addressing methane emissions is a particularly effective tactic for mitigating the near term impacts of climate change. Fuel cells are already generating electricity and heat, powered by methane from farmyard waste, food waste and waste water. The combustion of fossil fuels also creates black carbon, causing a feedback which is accelerating the melting of sea ice. Fuel cells convert fuel electrochemically without combustion, so there is no black carbon and other emissions are very low, or zero with renewable energy.