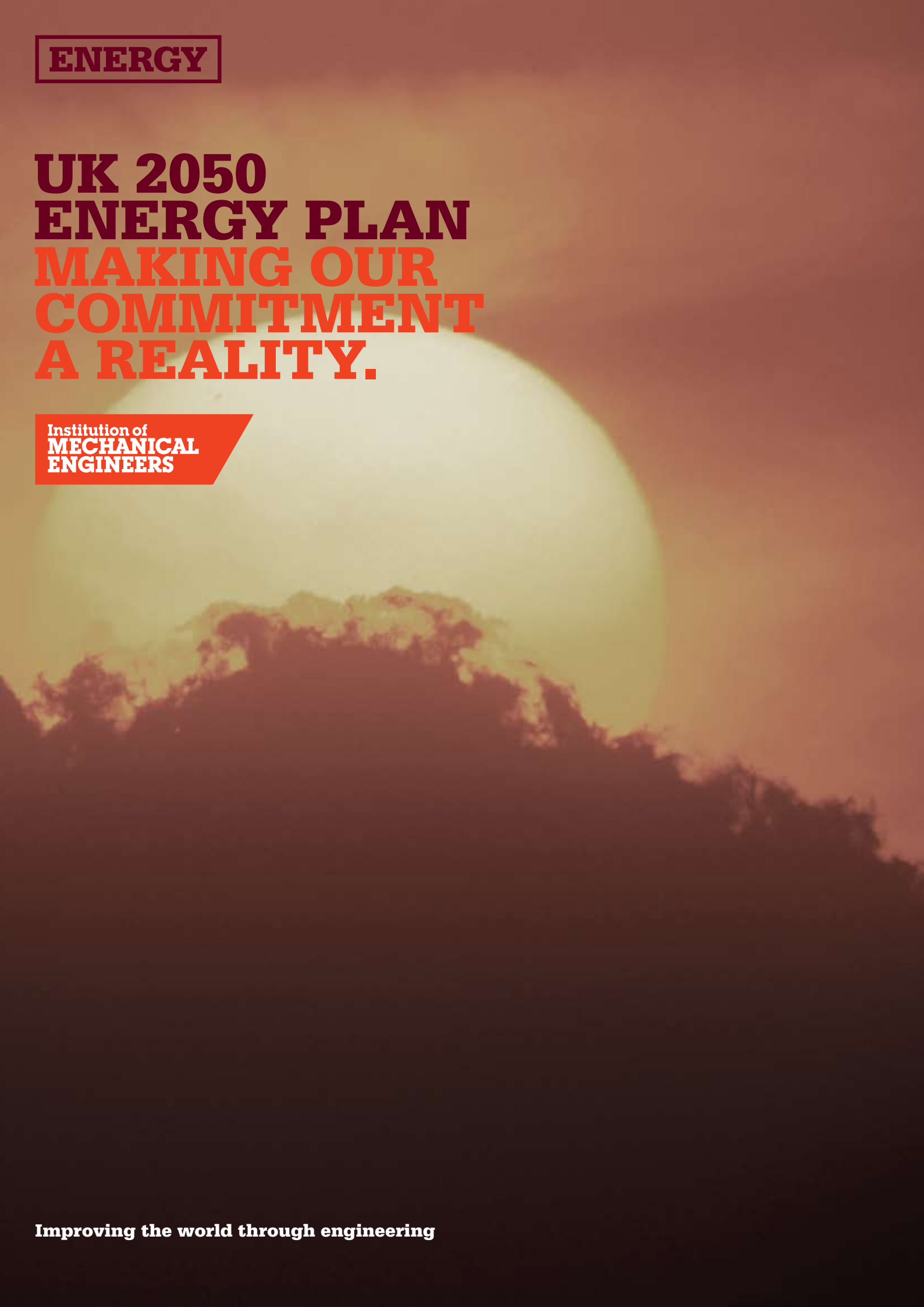
ENERGY

UK 2050 ENERGY PLAN

MAKING OUR COMMITMENT A REALITY.



Institution of MECHANICAL ENGINEERS

Improving the world through engineering

OVERCOMING CLIMATE CHANGE IS THE PRINCIPAL CHALLENGE FOR ENGINEERS IN THE 21ST CENTURY. TARGETS FOR THE REDUCTION OF CARBON EMISSIONS HAVE BEEN SET AT AROUND 80% FOR DEVELOPED NATIONS. SUCH RADICAL CHANGE NEEDS A WELL THOUGHT-THROUGH, CLEARLY DEFINED MASTERPLAN RATHER THAN INDIVIDUAL ACTIONS WHICH MAY OR MAY NOT SUCCEED.

DR COLIN BROWN
ENGINEERING DIRECTOR
INSTITUTION OF MECHANICAL ENGINEERS

The UK has committed to ambitious targets for the reduction of greenhouse gases by 2050. It is the Government's intention to pursue these targets vigorously at the COP15 negotiations in Copenhagen in December. This report by the Institution of Mechanical Engineers presents an energy plan for the UK that will make that commitment a reality.

This report has been produced in the context of the Institution's strategic themes of Energy, Environment, Education and Transport and its vision of 'Improving the world through engineering'.

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EXECUTIVE SUMMARY

This report presents the IMechE Energy Plan for the UK. It is part of the International 'Future Climate' Project coordinated by the Danish Society of Engineers in preparation for the COP15 meetings to be held in Copenhagen in December 2009.

Engineering will be one of the key sectors involved if the Climate Plan is to achieve its goals. New designs and new build on enormous scales will be needed to implement the different ways that society will need to operate in 20 to 40 years time. Engineers will play a vital role in many aspects of the changes, from the design and construction of infrastructure needed in new towns and existing urban areas, the design of energy efficient buildings with new materials and active environmental control at a level much beyond present standards, the design and provision of low carbon electric generators and electricity distribution, the design of new transport vehicles, and many other innovations that must be developed.

The overall objective of the Future Climate project is to contain the maximum global average temperature rise to within the guideline of 2°C. This is the primary assumption for this work and is not challenged. This assumption implies an average 50% reduction in global 'Kyoto' Greenhouse Gas (GHG) emissions relative to 1990 levels by 2050 which translates to an 80% or greater reduction target for the UK and other developed countries.

To meet this objective we propose that the total UK primary energy supply is targeted to reduce by at least 48% by 2050 (compared to 2006). The remaining supply must move to zero or low carbon sources to achieve a proposed overall 89% reduction in UK GHG emissions, relative to 2006. This equates to a 90% reduction in UK GHG emissions relative to 1990 levels and is so set to reflect a degree of over-planning and over-design that is necessary in risk management to ensure implementation is robust enough for the project target of an 80% reduction to be met. This is an important aspect of our plan. A plan conceived to exactly meet the target inherently carries the risk that if one technology does not deliver on time or at the performance that was anticipated then the target will be missed.

As with all developed countries the major energy users in the UK are Transport, Heating and Industrial.

The 48% reduction in primary energy supply will be made by:

- Improvements in vehicle efficiency, and a modal shift from road and short-haul air to rail and sea, resulting in a 50% reduction in transport energy use.
- Significantly reducing (space) heating demand, by using much improved thermal insulation and much improved heating systems, and widespread use of more efficient electrical devices, resulting in a 50% reduction in building energy use.
- Improving power generation efficiency, especially to capture both heat and power from new build facilities.
- Reducing industrial demand in a continued shift away from heavy manufacturing and making efficiency improvements to reduce energy consumption in the remaining sectors.
- Changes in agriculture leading to less processing and transport, with more emphasis on local supply.

Reductions in emissions will also be achieved by:

- Converting transport largely to electric vehicles reducing overall transport emissions by 90%.
- Switching primary energy supply from 91% fossil fuel to 69% low carbon or renewable sources (oil and gas use is cut 90% by 2050 and coal use is more than halved).
- Developing and using carbon capture and storage (CCS) for all large scale fossil fuel power generation and fossil fuel intensive process plant e.g. steel and cement.
- CCS or some alternative technology to allow clean coal power generation may be the most crucial technology in achieving global GHG reduction due to the widespread availability and low cost of coal and its key position in the energy generation of many countries including China, USA and Germany.

Consequences of the IMechE Climate Plan

- Major investment will be required to improve the electricity distribution grid, set up local heating networks, and encourage new clean energy sources. Increased water pumped and other electricity storage capacity will be needed to cope with the inherently greater intermittency of renewable sources. HVDC grid connections to other EU countries will be significant in allowing better management of the grid.

The plan will require government to put in place and maintain stable long-term policies that create investment environments in which commercial organisations can confidently commit to invest in the technologies and infrastructure necessary for meeting the target. Finance will be a major barrier to implementation if it is not forthcoming in a timely manner and a major investment demand will be created. It is vitally important that the various Government incentives available at any time are correctly targeted. Although Government policy will have to be very agile to meet the continuously changing needs of this complex programme, it will be important that these frameworks, which include the financial, legislative, regulatory and market tools that government uses to incentivise investments, are committed to by all political parties to ensure they do not change as the elected government changes.

Resources, both in terms of human and materials, together with training of skilled people for the new 'green' economy will be a major issue requiring national leadership. For example, the programme of work needed to complete the transformation to a low carbon economy will require significant numbers of nuclear engineers and their support, and a wide range of skilled building services engineering sector employees. There are large-scale opportunities for the creation and sustaining of 'green jobs' and green industries in the implementation of this plan.

Public engagement will be needed to help drive the change in our eating, food sourcing, heating and transport expectations. Behavioural change must be a crucial element in any plan as it is the key to energy demand reduction, improvements in energy efficiency and the acceptance of the technologies and infrastructure required to meet the plan. This is important in achieving streamlined and rapid implementation, particularly in allowing public approval for energy facilities and infrastructure to be built, and in ensuring that the engineering solutions to reduce energy consumptions deliver a step change in net reductions to consumers' heating and transport costs.

Key programmes of work are already underway in the UK to enable some of the new technologies of Carbon Capture and Storage (CCS), Electric and improved efficiency Vehicles and Smart Metering of buildings, but many more are needed.

The reward is not only a climate under control but also major business opportunities flowing from the new technologies needed. In essence we need nothing short of a second industrial revolution. The UK is extremely well placed to take advantage of this opportunity.

INTRODUCTION

Climate change is a complex issue.

As documented in the IPCC Special Report on Emissions Scenarios (Technical Summary) "Describing potential future developments involves inherent ambiguities and uncertainties. One and only one possible development path… simply does not exist alone".

The 'Future Climate' project offers an evidence-based methodology for addressing this complex issue. Future Climate is an international project involving thirteen participating national engineering associations to help address "an overwhelming need to reduce Greenhouse Gas (GHG) emissions to a sustainable level".

The common goal of all the national plans in the Future Climate project is to contribute to the reduction of the GHG emissions to a sustainable level. The project's definition of a "sustainable level" is the IPCC (Inter-governmental Panel on Climate Change) best case scenario whereby the increase in global temperature does not exceed 2°C[1,2].

This report documents the UK's contribution to the project, written by a working party formed by The Institution of Mechanical Engineers (IMechE)[3].

DESCRIPTION OF THE WORK CONDUCTED

THE IMECHE WORKING PARTY

A strong team of Senior Engineers from the IMechE have been assembled, together with external experts, to prepare this important report and:

- Include views drawn primarily from its Senior Engineers supported by the Institution secretariat.
- Represent a cross-section of expert views from within a range of industries, for example: energy companies, nuclear industry and renewables suppliers.
- Collaborate with recognised UK experts and thereby include detailed numerical baselines and forecasts.
- Where possible to achieve general consensus for any report and data which were produced across the wider UK engineering community.

The working party is detailed below:

Name	Engineering affiliation	
Alison Cooke (Lead contact)	Fellow, IMechE	Independent Consultant, Cooke Associates
Brian Cox (Lead Author)	Member, IMechE	Consultant, Shelford Business Consultants Ltd
Tim Fox	Key Theme Manager (Environment), IMechE	The Institution of Mechanical Engineers
Peter Guthrie	Fellow, ICE	Professor of Sustainable Development, Cambridge University
Nick Collings	Fellow, IMechE	Professor of Applied Thermodynamics, Cambridge University
Tim Hands	Member, IMechE	Cambustion Ltd
Tim Jackson	Fellow, IMechE Member, Power Industries Division	Energy Consultant, Sinclair Knight Merz
Tom Koskella	Associate Member, IMechE President's Apprentice	Mechanical Engineer, BP Plc
Lara Mallett	Business Development Manager, IMechE (Eastern)	The Institution of Mechanical Engineers
David Mackay	Fellow, The Royal Society	Professor of Natural Philosophy, Cambridge University
Michael Reid	Fellow, IMechE Vice Chair, Energy, Environment and Sustainability Group	Technology Director, Centre for Sustainable Engineering
Malcolm Van Den Bergh	Fellow, IMechE	Engineering Director, Trident Energy
Colin Brown	Engineering Director, IMechE	The Institution of Mechanical Engineers
Brian Robinson	Key Theme Manager (Energy), IMechE	(until May 2009)
Stephen Stretton	Research Associate	Cambridge Centre for Climate Change Mitigation, University of Cambridge

KEY TEXTS

A definitive 'official' UK National plan, to ensure that the 80% of 1990 Kyoto Greenhouse Gas emissions reduction target is achieved is still evolving. The IMechE working party identified three key documents to support their research.

1. **David J.C. Mackay**. Sustainable Energy – without the hot air,

   UIT Cambridge, 2008. ISBN 978-0-9544529-3-3

   Available free online from www.withouthotair.com

   (Professor Mackay is a member of the IMechE working party)

2. **Building a Low Carbon Economy – The UK's Contribution to Tackling Climate Change**, The First Report of the Committee on Climate Change.

   The Stationary Office London, December 2008 www.theccc.org.uk

   (The UK government has appointed the Committee on Climate Change to recommend what the level of the UK's carbon budgets should be. In its first report it recommends that "The UK should aim to reduce Kyoto GHG emissions by at least 80% below 1990 levels by 2050 (77% below 2005 levels)". This recommendation has been adopted by the UK government. This report makes recommendations for carbon budgets in the period up to 2020 but not beyond to 2050.)

3. **The Low Carbon Transition Plan**

   Issued by DECC on the 16 July 2009 as part of the UK Goverment's preparation for the COP15 discussions.

   www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

THE UK IMECHE WORKING PARTY METHODOLOGY

The members of the Working Party met in Cambridge on 11 May 2009 and considered the various aspects of the Future Climate project.

The working party divided into two groups to discuss and brainstorm the challenges presented and then reconvened to collect together overall ideas, structures and data for the UK Climate Plan.

Subsequent to the May workshop, designated individuals undertook to complete parts of the work prior to preparation of the final draft Climate Plan.

As National data and energy planning is evolving very fast, it is expected that this report will need to be updated frequently to take account of new information.

The following Assumptions were made in the consideration of the Climate Plan:

a. Population growth is assumed to be similar to 1950–2000, i.e assume no mass migration due to rising sea levels (eg. flooding of Bangladesh), major water shortages (eg. Australia, Africa), or sudden population growths (eg. cure for malaria or AIDS).

b. The Bruntland approach to sustainability is taken so that moderate economic growth is assumed: (1–2% pa)[25]. As defined by the Bruntland Commission: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

In addition, the working party recognised the need to differentiate between economic, viable and working technologies.

The following detailed assumptions were made to inform the work:

a. Figures were needed for the Baseline year (2006) and intermediate milestone years 2015 and 2030 leading to final target year 2050.

b. Energy needs and market sizes were expressed as PJ/y. The group also adopted the following conversion of 1GW = 28.3824PJ/y

c. UK current total energy consumption: 125KWh/day/person = 340GW assuming 60 million population.

d. The UK Climate Plan should achieve a minimum target of an 80% reduction in 'Kyoto' Greenhouse Gases (GHG) relative to 1990 level by 2050.

DESCRIPTION OF THE ENERGY SYSTEM AND THE SOURCES OF GHG

THE CURRENT UK ENERGY SYSTEM

The attached Energy Flow Chart 2007 (**Appendix C**) from the UK Department for Business Enterprise and Regulatory Reform (BERR now the Department of Business, Innovation and Skills – BIS) shows the inputs and outputs to the UK's energy distribution network[8]. Together with other data the following are the breakdowns for 2006.

Energy Input Analysis by fuel type and sector and associated UK GHG emissions for 2006 are:

Energy Usage by type	
Natural Gas	36.93%
Coal	17.73%
Nuclear	7.00%
Hydro & wind	0.07%
Petroleum	36.08%
Other	2.19%

Energy Usage by industry		**GHG Emission**
Industry	29.00%	122 $MTCO_2e$
Transport	34.00%	153 $MTCO_2e$
Housing related	26.00%	113 $MTCO_2e$
Agriculture etc	1.00%	44 $MTCO_2e$
Energy Sector	10.00%	221 $MTCO_2e$ (Power Stations 185)
Total		**653**

UK GOVERNMENT ENERGY SUPPLY POLICIES

The UK Government has recently made a number of decisions relating to the UK energy supply situation. New investment in energy supply is urgently needed as by 2015 half of the UK coal fired plants will be required to close under the EU Large Combustion Plant Directive. By 2020 all but one of the UK's nuclear power plants are also scheduled to have closed and many other coal fired power stations are soon approaching end of life, having operated for 50 years.

In 2008, the UK Government announced its commitment to building new nuclear power stations to replace the existing plant. In January 2009 proposals were published for the building of replacement nuclear capability.

In total around 30–35GW of investment in new electricity generation (both nuclear and non-nuclear) is planned within the next two decades. The new investment needs to be low-carbon. The Government is not placing a cap on the level of electricity to be generated by nuclear power. Various potential sites around the UK have been proposed for the new plant. The timetable for new build is as attached (**Appendix D**). According to this Pathway Document, power will start to be generated from the new plant from 2018.

On the 23 April 2009 the UK government gave the go ahead to the building of four new coal fired power stations with the condition that new plant must be fitted with CCS (Carbon Capture and Storage). Under the terms of the scheme, power companies will have to apply CCS to 400MW of power production, or a quarter to half of a typical coal plant, and would have to fit it to their entire output by 2025. The government expects the first plant to be ready by 2015[11].

UK NATIONAL CO_2 REDUCTION POLICY

The UK Government domestic goal is to reduce carbon dioxide emissions by 20% below 1990 levels by 2010[10].

In July 2008, the UK Government Department for Environment, Food and Rural Affairs (Defra) reported as follows:

"Final estimates for the 2006 emissions published in January 2008 show that emissions of the basket of greenhouse gases covered by the Kyoto Protocol fell by around ½% between 2005 and 2006, down from 655.5 to 652.3 million tonnes of carbon dioxide equivalent. Provisional estimates show carbon dioxide emissions during 2007 were around 543.7 million tonnes, 2% lower than the 2006 figure of 554.5 million tonnes. The decrease resulted from fuel switching from coal to natural gas for electricity generation, combined with lower fossil fuel consumption by households and industry"[9].

In the April 2009 budget the UK Government presented the first three carbon budgets, which aim to set the UK on a path to achieve the 80% reduction on 1990 emissions by 2050 as required by the Climate Change Act 2008 as follows

Emission Reductions to be:

- 22% below 1990 by 2008-2012
- 28% below 1990 by 2013-2017
- 34% below 1990 by 2018-2022

The 1990 reference level is taken to be 799 $MtCO_2e$[6].

In July the Department for Energy and Climate Change (DECC) issued the Low Carbon Transition Plan[38], giving an Integrated Energy Plan to 2020.

DESCRIPTION OF THE MOST IMPORTANT TECHNOLOGIES

DEMAND SIDE

The three largest parts of the UK energy demand are Building (Space) Heating, Transport and Industry. To achieve the desired GHG reduction the UK Climate Plan calls for the total UK energy supply to be reduced by nearly one half (48%). In addition the remaining energy needs must be met by low carbon or renewable sources.

To meet these goals, oil and gas fuelled vehicles need to be substantially replaced by electric alternatives and there needs to be a modal shift from road and short-haul air to rail/ship. Buildings need to be heated by electric heating (most likely heat pumps), or by heat supplied from local district heating schemes. Combined Heat and Power (CHP) systems using gas, biomass or waste as energy sources, or sustainable biomass heating are likely to be an interim choice until more efficient electric heat pumps become widespread. The buildings themselves must be insulated to a high standard. Industrial processes need to become more energy efficient and less carbon intensive, particularly in the case of the cement sector.

Transport
In 2006, the Eddington Transport Study was commissioned by the Government to look into the UK Transport system. It reported that 61 billion journeys per year are made in the UK and recommended that the Government should set three strategic economic priorities for transport policy which should be tackled: congested and growing city catchments; the key interurban corridors and the key international gateways that are showing signs of increasing congestion and unreliability[7].

In 2007, the Government commissioned the King Review to examine the vehicle and fuel technologies which over the next 25 years could help to 'decarbonise' road transport, particularly cars[35], and in July 2009 the Department for Transport (DfT) has issued "Low Carbon Transport"[36] as part of the UK Low carbon Economy Plan.

These reports give the basis for projections to 2050. As emissions from the transport sector are 24% of the current UK's total emissions, reducing transport related emissions is central to achieving the low carbon economy targets. More than half of the Transport related emissions are from passenger cars with little prospect of moving a significant portion of this to other transport means.

We assume that the use of private transport will remain much the same as today in the UK. This is far more optimistic than the UK Government projections which expect growth in demand from increasing population and increasing desire to travel. Our optimism comes from an anticipated societal change to more working near or at home and a greater stigma attached to unnecessary travel.

The development of low carbon transportation is seen in phases. Significant improvements in the efficiency of IC engine and hybrid cars should result in carbon emission levels of 130g/km by 2015, and 70g/km by 2030. Electric and fuel cell powered vehicles will lead to the realistic possibility of 30 g/km emission levels by 2050.

The introduction of more lightweight materials, improved aerodynamics, stop-start and the use of low rolling resistance tyres plus improved petrol/diesel engines should bring the vehicle fleet average emissions level down to between 80–100g/km.

Hybrid vehicles using a combination of IC engines running on biofuels and electrics will be able to bridge the gap between current vehicles and fully electric or longer term technology solutions.

Electric Vehicles have been in existence for many years but problems remain to achieve adequate battery power, storage capacity and weight efficiency for longer journeys. Electric cars suitable for city use at reasonable cost are becoming increasingly available, first as hybrids then as fully electric.

A network of plug in points for recharging is required in an electric car city. Current batteries need at least a few hours recharge time, so recharge points will need to be either at home or at work (probably both).

An alternative automated battery swap system has also been suggested. The further development of battery technology is very important. An additional potential for batteries is for them to be used as a store for excess wind generation or as an additional energy source in case of wind generation shortfall.

Road Freight
So far there is little sign of an electric vehicle capable of replacing long distance heavy goods trucks.

Much of this freight will need to move to electric rail transport or be replaced by locally produced goods.

Studies by Ricardo[37] show that for Heavy Goods Vehicles, the use of Aerodynamically designed truck bodies and better driving techniques could both significantly reduce truck CO_2 emissions.

Modal transfer of freight distribution movements to railfreight and local shipping have long been recognised as desirable and await investment in infrastructure.

There will be some necessary vehicles which cannot be electrified. For these vehicles biofuels are likely to be the immediate low carbon solution. The capacity for this is limited however as growing biofuels can adversely affect food production if uncontrolled.

The UK Government introduced a Biofuels requirement, the RTFO in 2007 but issued the following statement in 2008:

"The Renewables Transport Fuel Obligations (RTFO) Order 2007 came into force in April 2008 requiring that 2.5% of transport fuel must come from renewable sources in 2008-2009. The Government also commissioned the Gallagher Review in the light of concerns about biofuels, focusing particularly on the complex issue of the indirect or displacement effects of producing biofuel crops in developing countries. This review was published on 7 July 2008 and the Government will take its findings into account in UK and EU biofuel policies. In particular, the Government will consult later in the year on slowing down the proposed rate of increase in the RTFO"[9].

International Aviation and Shipping presents a problem because of the complexities of allocating international emissions to a National level[24]. As more than 90% of the UK's imports and exports are shipped by sea, maritime emissions are a concern to the UK government.

Current ship's engines face little or no restriction on emissions. Global agreement is needed to implement similar standards to those for stationary power generation.

It is becoming recognised that emissions from shipping also have health implications. Some actions such as reduced speed and cold ironing (in port use of shore electrical supplies) are starting to have a beneficial effect.

There is potential for more efficient engines and the possible use of wind power to increase efficiency. There may be a good case for a renewed investigation of nuclear powered ships.

There is also a lack of legislation on shipping fuels (e.g. Sulphur content), and a lack of control of fuel leakage.

Some energy demand savings for aviation can be made through the use of improved engine and fuselage technology as well as redesigned flight patterns to reduce long haul distances (and hence the fuel used to carry fuel). Ultimately biofuels represent the only technique available to significantly reduce aircraft emissions. A modal shift from short-haul air to high-speed rail is desirable.

Rail is already at capacity in the UK and with growing demand from modal shift, new lines particularly for freight moved from road transport, and increased capacity on existing lines is required. New high speed links for major cities in the UK and connecting to Continental high speed networks are also necessary. The proposed High Speed 2 link from London and ultimately to Scotland needs to be started.

Rail has the great advantage that it can be low carbon electrically powered without any new technology. Consequently all rail lines should be electrified over the next 20 years. It has been recently announced that the Western Mainline line to Bristol and Swansea will be electrified.

Heating of Buildings

The reduction of space heating demand from industrial users is easier to achieve than for domestic users. Individual companies and public buildings have good incentives to reduce their energy usage. The Carbon Trust offers energy audits and financial grants to commercial and public organisations with significant energy usage, and advises on the selection of suitable biomass heating systems and other carbon reduction schemes[12]. Local authorities have National Indicators to meet such as NI 185 Percentage CO_2 reduction for Local Authority Operations[18]. The Nottingham Declaration on Climate Change championed by the Energy Trust, has been signed up to by some 300 Local Authorities.

The UK Government has the opportunity and obligation to lead the way with positive policies on procurement in the refurbishment of public buildings – no refit without upgrade to carbon neutral standards of insulation for example. In this way the government would create a market for insulating products for retrofit that would reduce unit costs.

There are also a significant number of private consultancies assisting with energy efficiency improvements throughout the UK. Attached is an example case study of improvements made at Anglia Ruskin University, Cambridge[13] (**Appendix E**). Many large public sector Estate Management departments have now developed comprehensive policies covering the correct design and construction of Environmentally Sustainable New Buildings[14].

Domestic users present a more difficult challenge. There are about 22 million homes in the UK of which 80% at any time can be considered old in energy efficient terms. About 3 million "old" homes have been improved under various recent UK Government initiatives. Up to now these programmes have concentrated on improved insulation, but have not considered wide scale changes to electrical heating or the installation of local or district heating systems. One problem in the UK is that as there is a free market in energy, residents in any one street can choose their energy supplies from several different suppliers. This makes it difficult to organize efficient street by street conversion or improvement.

The current efficiency measures under the UK CERT (Carbon Emission Reduction Target) scheme for insulation are expected to be complete by 2015, Therefore more community based approaches are proposed under further schemes (CESP and HESS). Several organisations and political parties have also proposed that the Centrica "Green Streets" initiative is rolled out across the UK. This will involve advising on whole house energy efficiency measures, possibly with grant funding for those measures selected by the owner.

A recent report for the Department for Energy and Climate Change (DECC) by Poyry Energy Consulting and Faber (AECOM) reviews the cost and benefits of district Heating. The report suggests 5.5 million UK homes could be economically connected to district heating.

New build housing should achieve high levels of sustainability for example with built in Solar panels. Some proportion of existing building stock may need to be demolished because the cost of refurbishment to higher energy efficiency is too much.

The waste heat from power stations currently sent to cooling towers or the sea (in the case of Nuclear plant) offers a solution to overdependence on the electric economy if sensible and efficient ways can be found to harness this waste energy.

Agriculture

Agriculture generates about 7% of the UK's emissions. Agriculture and landfill both generate methane. An estimated 55% of the impact of GHGs from agriculture are Nitrous Oxides. Both Nitrous Oxide and Methane are more powerful GHGs than CO_2[28]. Agriculture, food processing and the food distribution system are major emitters of greenhouse gases, producing at least 18% of the UK's total greenhouse gas emissions[4].

As well as increased efficiency of the industrial processes involved in the food stream, different fertilizers, an emphasis on local supply and changes to diet, may need to develop over the next 30 years.

Land use change is not a significant element of the emission equation in the UK.

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A RECENT REPORT FOR THE DEPARTMENT FOR ENERGY AND CLIMATE CHANGE (DECC) BY POYRY ENERGY CONSULTING AND FABER (AECOM) REVIEWS THE COST AND BENEFITS OF DISTRICT HEATING. THE REPORT SUGGESTS 5.5 MILLION UK HOMES COULD BE ECONOMICALLY CONNECTED TO DISTRICT HEATING.

Industry
Some heavy process Industries will be amongst the remaining users of fossil fuels.

Cement production is a big CO_2 emitter.

The World Business Council for Sustainable Development in it's Cement Sustainability Initiative[39] lists four "levers" available to the industry to reduce emissions:

- Improved Energy Efficiency
- Alternative Heating fuels
- Use of blending materials, for example: Power station fly ash
- Linking to CCS systems

Over half of the world's cement production is currently in China and other developing countries.

Steel Production is another big emitter and should also link to CCS network. As with all large industrial plant there are still in many cases wide ranging opportunities for short and medium term emission reduction through energy efficiency measures.

Over time, Process industries use of natural gas will be replaces by use of syngas and Fischer-Tropsch products produced from coal with CCS, biomass or waste.

SUPPLY SIDE

The UK power industry has in the recent past, been based on large scale generating plant connected to a National Grid. These require high energy density fuels and operate as GW sized facilities. The move to renewable forms of energy at lower energy densities typically means a larger number of facilities to generate the same level of power. This does however have the benefit that the plants can become a community asset and meet the local needs.

In a country district for example, biomass fuel may be easily available and a village wide biomass heating network can be constructed at reasonable cost. Many of these are already underway across the UK.

In towns, waste may be a good source of both electric power and heating. The IMechE report "Energy from Waste" points out that the UK is far behind the rest of Europe in its use of waste as a fuel. Several modern Energy from Waste (EfW) plants are now under construction or have recently been completed such as the PREL plant at Peterborough and the Hampshire waste plants. Modern EfW plants can also recover glassy and metal by-products and target zero to landfill results. These smaller local plants can achieve high overall efficiency by supplying a mix of electric power, heat and recovered materials[16,17,19].

There is some discussion concerning the achievement of a good balance between EfW and re-use/re-cycling.

Major coal fired power plants have overall efficiencies of the order of only 30% (although modern gas fired Combined Cycle Gas Turbine replacements would achieve over 40% or 50%), much of the balance being wasted as heat sent to cooling towers. As many of the larger power stations are remote from residential housing, there is little further potential to capture and use this heat for local needs.

Government incentives are needed to encourage the movement of heat from large power plants to towns. The current drafting of the UK Section 36 legislation discourages new stations from being located near heat loads so this needs attention. Where both new housing and new power plant are being built there needs to be good coordination between the various Government departments involved to ensure overall good results.

For older houses, fuel cell Combined Heat and Power (CHP) for low density areas, and district heating CHP for high density areas, may be a good solution for the next 20 years as the grid has not yet been decarbonised enough to justify air source heat pumps everywhere. At some point around 2030 this is likely to change.

One result of a major transfer of demand to electricity is the effect on the supply grid. If too many homes turn on electric heating and too many electric cars are plugged in for recharging at the same time then the existing electricity distribution grid may well fail. The full electrification of transport would approximately double the electricity generation required, and for wind generation a higher capacity network will be required as many design criteria are based on the peak generation rather than the average (25–30% of peak).

Power stations

Nuclear – a large new nuclear build programme is required to deliver about 20GW capacity by 2030, and 25GW by 2050. Resolution of long term waste repository is needed. Also current technology uses uranium inefficiently, meaning that current reserves will only last approximately 100 years, which is similar to current forecasts for natural gas. New fast breeder technology is required to make nuclear power sustainable.

Nuclear Fusion is currently only at the experimental stage. However a technical breakthrough in fusion would change the whole picture and hence research should be continued.

Coal power stations need to develop to have close to zero emission (based on CCS being successful and becoming universal). Two demonstration phases by 2020 are expected to be commercially viable (with subsidy). Currently in the first UK demonstration phase are four demonstrators – Oxyfuel (Schwartze Pumpe, Doosan Babcock), IGCC (Hatfield), Capture (Alstom, Great Plains Synfuel, Didcot), Storage (Insalah, Weyburn, Sleipner).

Gas power stations will also have to be close to zero emission based on the same CCS technology. Because of their lower initial emissions they are expected to follow coal implementation by around 10–20 years.

Wind – large scale offshore, potentially mandating for onshore in agricultural areas.

Tidal – tidal current power generation is at the demonstration phase. Barrage type tidal energy generation is proven technology but needs large scale expansion. Tidal current appears to have less environmental impact and is smaller scale and therefore easier to implement.

Wave – several prototypes are in the demonstration phase.

Solar – PV is established and gradually becoming more competitive. There is renewed interest in Concentrated Solar Power in Desert regions[40].

Biomass – has a large potential but great care needs to be taken to make sure that it is sustainable, reduces CO_2 emissions and benefits rather than exploits developing countries[12,15].

Waste – there is a need to investigate the lifecycle benefits of recycling versus energy from waste. Ideally waste should be reused or recycled close to where it is produced. The next best option is to use waste in an EfW facility to produce power and district heating for the community producing the waste. The National Farmers Union has already identified 2GW of generation potential from Anaerobic Digestion plants.

Geothermal – The European Geothermal Energy Council predicts geothermal in the EU27 to increase from 800MW to 6GW by 2020. Geothermal is less relevant in the UK, where there is potential in only a few areas.

Fossil fuel recovery and processing. It is assumed that little oil and gas is used, and that this is for process use rather than for energy use.

It is expected that some gas will continue to be imported.

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THE REWARD IS NOT ONLY A CLIMATE UNDER CONTROL BUT ALSO MAJOR BUSINESS OPPORTUNITIES FLOWING FROM THE NEW TECHNOLOGIES NEEDED. IN ESSENCE WE NEED NORTHING SHORT OF A SECOND INDUSTRIAL REVOLUTION.

TOTAL CLIMATE PLAN

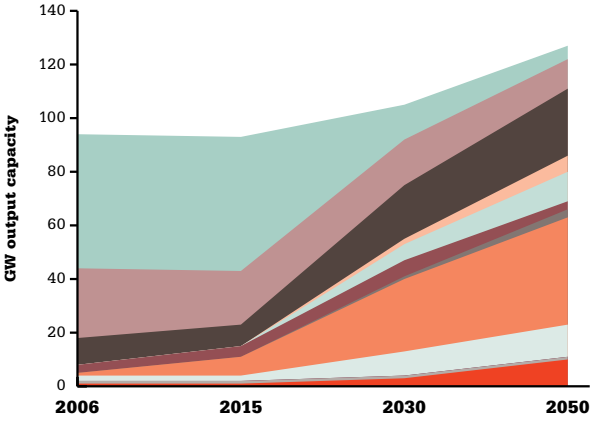
The Energy supply for the Climate Model for 2050 proposed by the IMechE Working Party is shown below and this has been partly based on the energy plans developed by D Mackay[5,29]. **Appendix A** shows the UK Climate Action Plan which provides a roadmap for reaching the outcome and includes the main assumptions used to generate the energy supply and emissions data presented in the data sheet at **Appendix B**.

GW output capacity

	2006	2015	2030	2050
Net Imports	1	1	3	10
Hydropower	1	1	1	1
Geothermal	0	0	0	0
Biomass	2	2	9	12
Wind	1	7	27	40
Solar Heat	0	0	1	3
Waste	3	4	6	3
Wave and Tidal	0	0	6	11
Photovoltaic	0	0	2	6
Nuclear	10	8	20	25
Coal	26	20	17	11
Gas (e)	50	50	13	5
Total				**127**

Coal and Gas CCS from 2030
Imports include solar power from abroad.

Note that the above data is the required delivered GW output capacity to meet the expected demand. Utilisation for fossil and nuclear plant is about 0.8 and the load factor for wind is about 0.3, so that the installed capacity has to be larger by these factors.



Energy supply capacities
Despite the Climate Plan delivering a 48% reduction in UK primary energy supply the remaining capacities called for are extremely challenging as many of these proposed energy sources have not yet been developed to the required industrial level. Comments on the individual technologies are as follows:

Nuclear: This plan calls for a total of about 16 power plants equivalent to the existing 1.2GW Sizewell power station by 2030, and another 4 by 2050 giving a total of 25GW capacity. Current UK Government plans are for only 9 new stations, so this implies a second phase of construction. For comparison France currently has 64GW of installed Nuclear Power.

Wind: A massive expansion of wind energy is required. Currently the largest onshore wind farm in the UK is Scottish Power's installation at Whitelee, this has 140 turbines with a capacity of 322MW but is planned to increase to 221 turbines with a peak capacity of 614MW.

The largest offshore wind farm planned in the UK is the London Array. This will have 341 Turbines and a peak capacity of 1GW or about 1% of UK demand

Biomass: There are numerous small scale biomass generator units installed in the UK mainly using dry fuels (woodchip, straw, energy crops) Several large scale projects have also been built and are planned (Lockerbie, Prenergy, Helius, Drax).

Anaerobic digestion has been used for some years by UK Water Companies. Severn Trent have three sites where digestion units feed gas engines used to supply electricity to the sewage works[20]. Anaerobic Digestion is also widely used in Europe.

Solar electric: PV is an existing technology but currently too expensive for widespread adoption. The future may be PV solar or solar concentrator farms in desert areas such as proposed by Desertec[40].

Solar thermal: This refers to water pumped systems. These are widely available with improving performance. They can be an economic pre-heater for domestic hot water systems and should be more widely used than they currently are.

Waste: Energy from waste plants are now being increasingly planned and built in the UK. The use of Plasma systems to recover metals and minerals from the resulting ash offers zero to landfill capability but needs installed experience.

Hydro: Hydro power generation is well established in Scotland but there are only a few other suitable regions in the UK for Hydro installation, similar to the newly constructed Glen Doe facility. Mini turbines and run-of-river have a limited role in local power generation.

Geothermal: The UK has one geothermal generation system in Southampton. There is possible potential in several other areas.

Tide and Wave Power must be considered as early stage technologies at present. It may take 10 years of experience of before there is realistic data to support large scale investment. The Severn Barrage project is currently under consideration for Government funding.

Tidal stream is extremely attractive to power supply companies because of its predictability. As usual, the most powerful tidal streams present the most hostile environment. The industry is still looking for a technology which is commercially viable in less hostile environments and in shallower water.

Energy Supply Issues

Many of the above energy generation technologies may be considered as developed and available. However the total demand planned in the above Climate Plan for many of these technologies requires new plant builds on a massive scale. This presents political/social problems rather than technology problems.

The adoption of the above plan also requires significant improvements to the UK National Electricity Grid. The existing grid is based on large power plant and a gradually diminishing demand network in remote areas.

The proposed scenario requires both the ability to transmit energy from remote wind, wave, and tidal installations; accept input energy surpluses from local power plant and supply an overall increased demand for electricity. Renewables will contribute some 40% of all UK primary energy supply by 2050; up from 2% in 2006. This will require a major government backed upgrade of the National Grid and for the UK to play a full part in a European and North African 'Super Grid'.

Although coal use is more than halved by 2050 there is still a need for substantial capacity and therefore CCS for coal requires major development; there is only very limited experience to date. New trials are now starting.

Energy storage will be of increasing importance to smooth sustainable power generation. Pumped storage projects offer a good solution. Some 10GW of storage capacity may be needed.

DESCRIPTION OF THE MEASURES REQUIRED

Key programmes of work are already underway to enable the new technologies of Carbon Capture and Storage (CCS), Electric Vehicles and Smart Metering of buildings.

Carbon Capture and Storage
Developing and using carbon capture and storage (CCS) for all large scale fossil fuel power generation and fossil fuel intensive process plant e.g. steel and cement is critical to the future low carbon economy.

CCS or some alternative technology to allow clean coal power generation may be the most crucial technology in achieving global GHG reduction due to the widespread availability and low cost of coal and it's key position in the energy generation of many countries including China, USA and Germany.

There is extensive work underway across the world to investigate and develop this process.

According to the UK's Carbon Capture and Storage Association, the UK has at least 10 projects in the pipeline[30]. Some of these are:

- Scottish Power have launched a pilot CCS project at the 2.3MW Longannet coal fired plant in Fife. The test unit will operate on 1MW for some seven months before a full scale unit is ready.
- E.ON and the Engineering and Physical Sciences Research Council (EPSRC) have announced a collaboration project at four Universities. The University of Nottingham will investigate CO_2 capture. Newcastle University will investigate CO_2 transport. A group at Leeds University will study oxyfuel combustion, and a consortium led by the University of Edinburgh will investigate the economics of large scale CCS.
- Internationally, the European Commission has announced plans to allocate up to €50 million for the construction and operation of a CCS demonstration project in China, as part of the EU China Near Zero Emissions Coal Plant project.

Electric Vehicles
Currently only a very small number of fully electric cars are on UK roads. They underperform internal combustion engine vehicles and are typically more expensive. Government support and intervention is essential to help develop the technology.

The Department of Transport's "Strategy for a Low Carbon Future" was launched in April 2009. This strategy includes incentives to encourage consumers to purchase electric vehicles, and help to establish a network of charging points in "electric car cities"[32].

The Technology Strategy Board's "Low Carbon Vehicles Innovation Programme" supports the development of innovations in electric car development.

The first Low Carbon Vehicle Innovation Platform competition was launched by the Technology Strategy Board and the Department for Transport, in September 2007. It allocated more than £20m of investment to support Low Carbon Vehicle research, development and demonstration projects.

In 2009 two more research and development competitions have been launched:

- Ultra-low carbon vehicle demonstrators
- Ultra-efficient systems for the market advancement of electric and hybrid vehicles[34].

There is a long history of electric commercial vehicle building in the UK including the famous electric milk float, and trolley bus overhead line passenger vehicles. New designs of electric commercial vehicles are now being ordered by a number of UK organisations.

New investment in a factory in the North East of England to produce batteries for electric vehicles has recently been announced subject to EU approval.

Building Energy Efficiency Improvement
Compared to the German Passivhaus standard of total power consumption of 13.7 watts/m^2, UK average houses use about 30 watts/m^2. Offices are similar or more. There is therefore a significant opportunity to reduce heat demand through better insulation.

The UK housing stock is about 22million homes. Based on typical new build figures, some 80% of the 2050 homes are considered to be already built. Of the current stock some 7 million have solid brick walls and are more difficult to insulate well.

The UK Government has announced that it intends to mandate smart meters for all households with a completion target of 2020[31].

It is expected that smart meters will play an important role in achieving the low carbon economy by providing householders with the ability to control and reduce energy usage and costs. Energy companies will also be able to increase their efficiencies and both will be able to identify the worst case homes.

For new buildings, UK Building regulations Part L Conservation of Fuel and Power apply. The Chartered Institute of Building Service Engineers provides guidance and training on the achievement of low carbon buildings.

Current thinking is that heat pumps provide the best heating efficiency where district heating is not suitable. However there are problems of installation and noise for the airhandling units. In some cases with good insulation, simpler electric heating combined with solar thermal panels may be a good solution.

The Committee on Climate Change has re-evaluated the National cost of achieving the Low carbon economy required.

The conclusion is that, as proposed by the earlier Stern Report, the cost will be of the order of 1% of GDP.

Within this National economic figure it is important that the various Government Incentives at any one time are correctly targeted. Finance will be a major barrier to implementation if it is not forthcoming in a timely manner and a major investment demand will be created. Government policy will have to be very agile to meet the continuously changing needs of this complex programme.

In view of the UK Government's commitment to a substantial increase in the use of renewable energy, the House of Lords Economic Affairs Committee decided to examine the economics of renewable energy[41].

Their investigation looked at the relative cost of renewables and the effect of increased renewable on the average cost of generating electricity.

Some of their conclusions were :

- Para 75: The cost of electricity from onshore wind farms at good locations would only be comparable with that from fossil fuel generators when prices of oil, gas and coal are very high or allowance is made for the price imposed for carbon emissions permits (effectively a tax). It is more expensive than nuclear generated power. In our base case, onshore wind cost 7 pence per kWh, as opposed to around 4 pence per kWh for the other technologies – coal, gas and nuclear. Offshore wind, biomass, wave and tidal power are even more expensive. And these estimates exclude the additional costs of integrating more renewable generation into Britain's electricity grid.
- Para 85: Future developments in the base generation costs of electricity from renewable sources depend upon many variable factors such as technological development, the rate of return required by generators and construction costs. But from the evidence we have seen it seems clear that as things stand the base costs of generation of electricity from onshore wind are likely to remain considerably higher than those of fossil or nuclear generation and that costs of generation of marine or solar renewable electricity are higher still.
- Para 163: Harnessing renewable sources of heat is often cheaper than for electricity generation and offers a larger target area, as heat accounts for double the final energy demand of electricity. There is no intermittency problem with renewable heat. We recommend that the Government should lay at least as much emphasis on encouraging the development and use of renewable heat as on renewable electricity generation.

SECURITY OF SUPPLY

The suggested Plan offers good security of supply both on an International scale and at a local level. The current UK energy profile is heavily dependent on imported gas over the next few years.

New Interconnections for electricity transfer between EU countries can also increase the security of supply.

From the point of view of local supply within the UK, the much increased use of electricity for heating and transport means that continuity of supply is even more critical. Given the likelihood of increased storms and other climatic causes of power outages, the new Grid needs to be designed with increased resilience.

Localised power generation either from renewables or clean fossil fuel based systems will tend to give the needed local resilience and continuity of supply.

INNOVATION, BUSINESS AND JOB CREATION POTENTIAL

The major programme of work needed to complete the transformation to a low carbon economy will require significant numbers of nuclear industry engineers and support, and a wide range of skilled building services engineering sector employees amongst others. Training of these people will require National leadership.

There will be major business opportunities flowing from the new businesses that will need to be generated. The UK is extremely well placed to take advantage of this opportunity.

APPENDIX A

IMECHE UK CLIMATE ACTION PLAN

		2015	2030	2050
Demand-side	**Buildings**	Accelerated programme of building refurbishment, especially wall, floor and loft insulation and replacement of old, inefficient boilers with high efficiency modern equivalents (gas condensing and/or biomass).	All existing buildings that can be sensibly upgraded to modern standards have been so upgraded. Those that can't and that aren't of architectural/historical importance are gradually being demolished and replaced. All new houses and many existing ones now having their remaining (low) heat demand met by electricity via heat pumps or district heating.	Improvements in building energy efficiency and the efficiency of electrical appliances have resulted in overall energy use in the housing sector falling by 50% since 2006.
	Transport	Strong societal, legislative and fiscal incentives for motorists to switch to "best in class" models. Owning and driving a car that does less than 40mpg viewed as no more socially acceptable than drink-driving. Battery electric vehicles and plug-in hybrids beginning to achieve significant market share.	Vehicle fleet now predominantly high-efficiency electric. Vehicles still using liquid fuels do so with high blends of bio-fuels. Visible and significant evidence of global warming and its catastrophic effects has led to demand for fossil-fuelled air travel being greatly reduced.	Improvements in vehicle efficiency and modal shift (e.g. from road freight to rail/sea) have more than halved transport energy use since 2006.
	Industry	Manufacturing output returns to pre-recession (of 2008/9) levels, but higher fossil fuel prices, legislation and carbon trading regimes lead to increased focus on energy efficiency, particularly through industrial CHP.	Further improvements in efficiency mean that overall demand is falling gradually despite growth in output.	Continuing improvements in efficiency mean that the trend for overall demand to fall gradually, will remain.
Supply-side	**Fossil fuels**	Improvements in building and vehicle efficiency combine with greater supply of renewable energy to reduce demand for oil and gas. Use of coal falls in line with shut down of older plants and emissions trading regimes.	Changes in buildings and transport have led to dramatic falls in gas and oil use. Coal still has fairly major role in electricity production but Carbon Capture and Storage technology has been introduced to reduce overall emissions from coal from about 0.09 $MTCO_2e$ per primary PJ supplied in 2006 to 0.06 $MTCO_2e$ per PJ in 2030.	Apart from some residual use in transport, industry and for grid-balancing, oil and gas use is now almost eliminated – both down more than 90% on 2006 levels. Coal use also down on 2030 levels, but still major supplier of electricity (and industrial heat). CCS technology has reduced emissions from coal to 0.05 $MTCO_2e$ per PJ supplied.
	Nuclear	Some more existing plants have shut down. New build programme finalised and construction of first plants underway. Second phase build programme being planned.	Main new build programme now complete, delivering 600 PJ per year, equivalent to about 32GW. New build assumed to be only on sites previously used by nuclear industry, with each site supplying 2–3GW.	Plants built during 2010s and 2020s still supplying 750 PJ per annum. Plans being developed to replace them (as they reach end of their 40 year design life) with renewables and/or fusion reactors.
	Renewables	Feed-In Tariffs and Renewable Heat Incentive set high enough to encourage micro-generation, e.g. of solar heat and PV. Planning and grid-connection issues for on-shore wind sorted out and major programme offshore has delivered about 7GW of wind energy. Waste seen as a resource for both materials and energy, so town-scale Energy from Waste plants are now much more common and widely accepted (and the Renewable Heat Incentive (RHI) has ensured they are a key and growing part of many district heating schemes).	Building refurbishment and new construction programmes assumed to be delivering significant investment in solar heat and PV. Publicly funded R,D&D during the early 2010s has brought the costs of PV down and efficiencies up. Wind power is now fully cost competitive with other supply options, and is expanding rapidly – 3-5GW of new wind is being connected each year, and has been since 2015. R,D&D in the 2010s has also allowed for a major expansion in biomass energy use, using 2nd and 3rd generation bio-fuels from sustainable sources. A Severn Barrage has been built and other forms of wave and tidal energy are increasingly used.	Further expansion of wind, PV, solar heat, biomass, wave and tidal energy, at PJ/year growth rates similar to those achieved in the 2020s. A move to a more resource efficient society has led to a reduction in volumes of waste available for energy conversion, so EfW supply has fallen since 2030.
	Electricity imports	New interconnectors built as first stage in EU supported "Supergrid" to link low carbon energy supply sources across Europe and North Africa to points of demand.	Further development of the Supergrid and interconnectors has allowed more import and export of electricity to provide grid balancing services.	Concentrated Solar Power from North Africa now a major supplier to the UK grid, with excess wind energy being regularly exported.

APPENDIX B

DATA SHEET FOR THE CLIMATE PLANS

			Baseline 2006	Climate Plan 2015	2030	2050
GHG emissions ($MTCO_2$ equivalents)	CO_2		556	482	202	55
	Methane		49	45	25	10
	Nitrous oxide		38	35	25	8
	HFC/PFC/SF6		10	8	5	2
	Total		**653**	**570**	**257**	**75**
GHG emissions by source sector ($MTCO_2$ equivalents)	Power stations		185	160	50	18
	Industrial processes		122	115	80	30
	Transportation fuels		153	135	45	16
	Agriculture		44	40	30	5
	Fossil fuel retrieval processing and distribution		16	10	2	1
	Residential, commercial and other sources		113	90	30	0
	Land use and biomass burning		-2	0	0	0
	Waste disposal and treatment		22	20	20	5
	Total		**653**	**570**	**257**	**75**
	% fall from Baseline			13%	61%	89%
	% fall from 1990 (780 $MTCO_2e$)		16%	27%	67%	90%
Energy consumption by sector (PJ)	Transport		2,503	2,400	1,600	1,200
	Agriculture, forest and fishing		38	35	30	20
	Industry, construction, wholesale, private and public service		2,158	2,100	1,950	1,750
	Housing		1,908	1750	1250	950
	Energy sector (production and distribution)		798	750	700	400
	Total		**7,405**	**7,035**	**5,530**	**4,320**
Primary energy supply (PJ)	Oil		3,685	3,450	1,400	300
	Gas (heating)		3,771	3,775	2,000	300
	Gas (electricity generation)					
	Coal		1,811	1,400	1,200	750
	Nuclear		717	600	1,500	1,875
	Waste		103	125	200	100
	Biomass		62	65	300	400
	Geothermal		1	1	2	5
	Solar heat		1	2	40	80
	RE Electricity:	Wind	15	200	800	1,200
		Photovoltaic	0	5	50	160
		Hydropower	17	17	20	20
		Wave and tidal	0	1	175	325
	Other:	Net imports of electricity	27	35	100	300
	Total		**10,210**	**9,676**	**7,787**	**5,815**
Installed effect			75	100	200	250
Ratio of RE to the total energy supply (%)			1.9%	4.3%	20.4%	39.4%
Energy import (PJ)	Oil		3,944	3,000	1,250	300
	Gas		879	2,500	1,500	300
	Coal		1,366	1,200	1,000	500
	Biomass		21	30	100	200
	Electricity		37	55	150	400
	Uranium		717	600	1,000	1,000
	Total		**6,964**	**7,385**	**5,000**	**2,700**
Energy export (PJ)	Oil		3,615	1,000	0	0
	Gas		434	0	0	0
	Coal		14	0	0	0
	Biomass		0	0	0	0
	Electricity		10	20	50	100
	Uranium		0	0	0	0
	Total		**4,073**	**1,020**	**50**	**100**

APPENDIX C

UK ENERGY FLOW CHART 2007 (MILLION TONNES OF OIL EQUIVALENT)

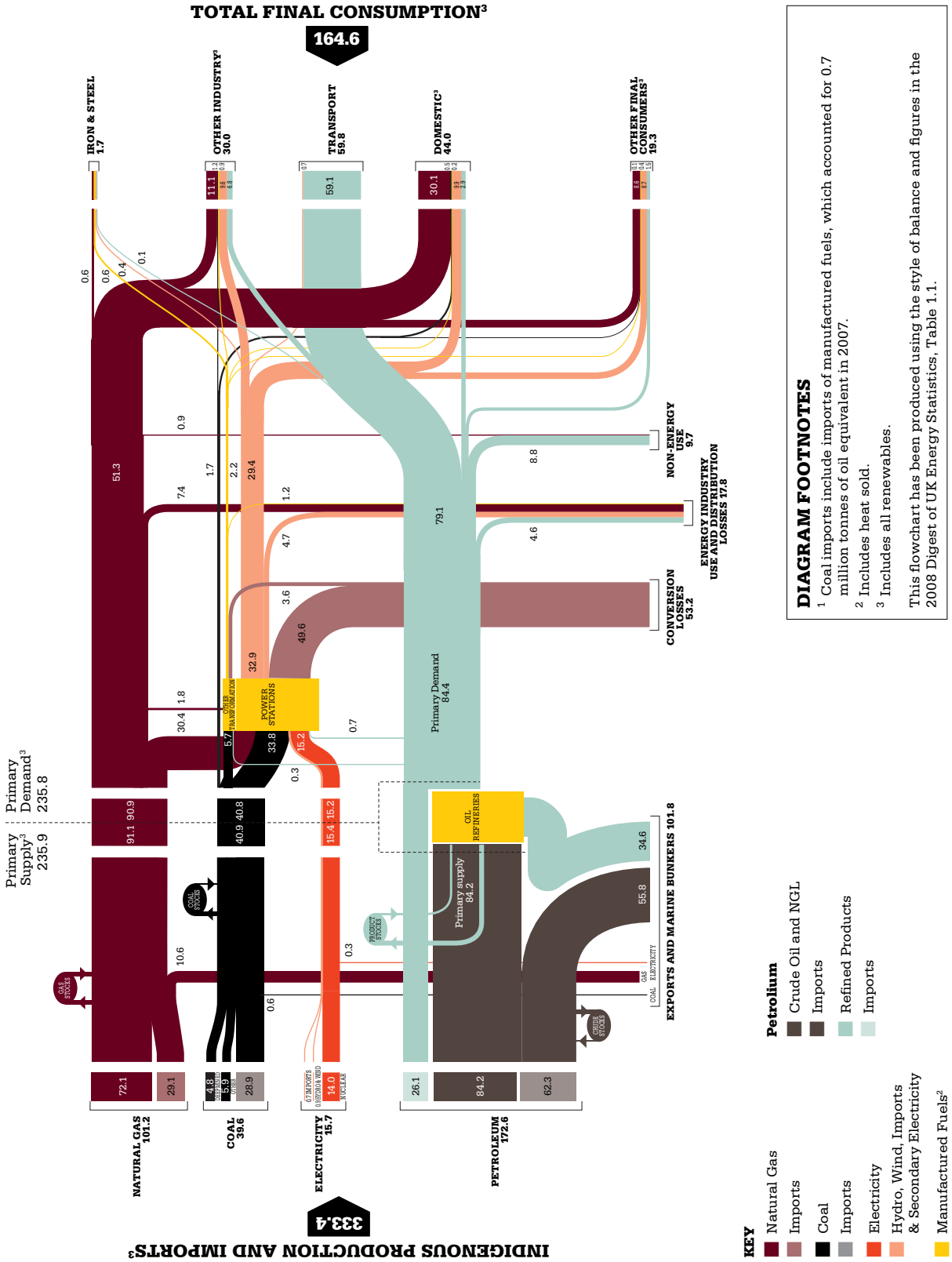


DIAGRAM FOOTNOTES

[1] Coal imports include imports of manufactured fuels, which accounted for 0.7 million tonnes of oil equivalent in 2007.

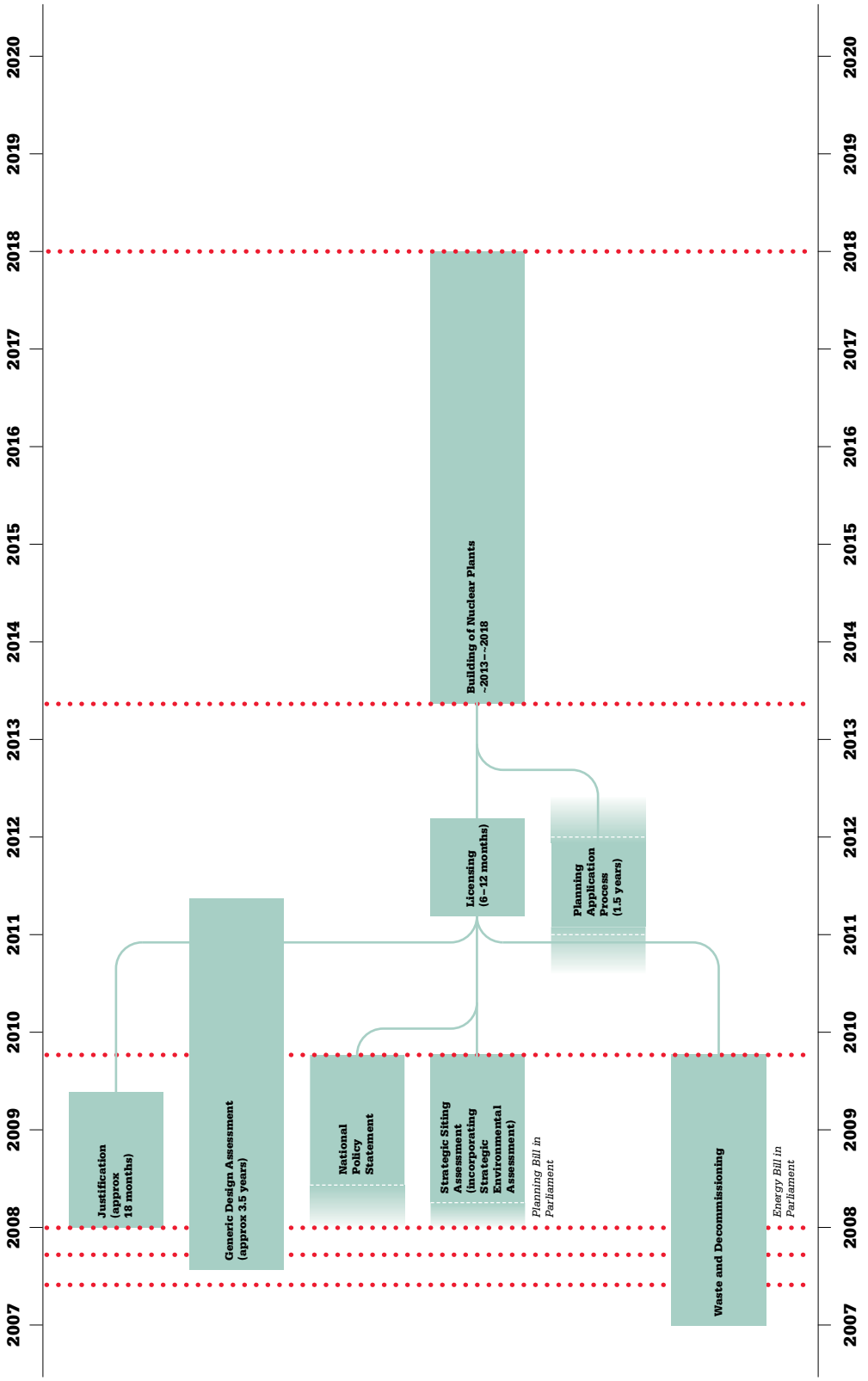
[2] Includes heat sold.

[3] Includes all renewables.

This flowchart has been produced using the style of balance and figures in the 2008 Digest of UK Energy Statistics, Table 1.1.

APPENDIX D

INDICATIVE PATHWAY TO POSSIBLE NEW NUCLEAR POWER STATIONS



APPENDIX E

The Organisation
Anglia Ruskin University has campuses in Chelmsford and Cambridge and over 26,000 students. Its energy budget for 2007/08 was in excess of £1.5 million.

Monitoring and Targeting (M&T)
TEAM software was used to monitor and target (M&T) energy use in conjunction with manual meter reading and invoices – a labour intensive process that does not provide reliable data. Timing, accuracy and accessibility are major obstacles, in particular the lack of metering for electricity on a building level.

Automatic meter reading (aMR) and monitoring and targeting (aM&T) was seen as an effective route to improvement and The Green Consultancy was commissioned to advise on implementation.

We recommended both aMR and aM&T as effective ways to automate and improve his management reporting and M&T functions and to achieve annual savings estimated at 891,500kWh and 320 tonnes of Carbon Dioxide.

The university has recently implemented these recommendations. Chelmsford uses Enercom logging meters and Cambridge is using El Component. At the time of writing the systems were being commissioned and the intention is to link them to web enabled software.

Once the systems are fully commissioned, manual meter reading will be largely eliminated, freeing up direct labour, providing reliable data and allowing effective energy management and waste detection.

This will allow the University to:

- improve on savings being achieved through bill validation/checking
- make new savings through early detection of waste/poor performance
- target its energy savings effort on a building by building basis
- quantify the achievements of its energy management programme
- provide meaningful utility reports to higher management
- procure its fuels more efficiently
- and in the long term institute a system for sub-billing its departments

See ref 13.

> **“WE HAVE USED THE GREEN CONSULTANCY FOR TWO INVESTIGATIVE PROJECTS FOCUSING ON ENERGY MANAGEMENT, METERING, BUILDING MANAGEMENT SYSTEMS AND PLANT ISSUES. THE SERVICE HAS BEEN VERY GOOD AND THE OUTCOMES AND RECOMMENDATIONS CONCISE, ACCURATE AND VERY USEFUL.”**
>
> **MARK NORMAN**
> **ENVIRONMENTAL MANAGER**
> **ANGLIA RUSKIN UNIVERSITY**

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