Institution of Mechanical Engineers, 'UK 2050 Energy Plan: Making our commitment a reality' (2009)

1. Purpose of the activity

Represents the IMechE Energy Plan for the UK. Forms a part of the International `Future Climate' Project which was prepared for the Copenhagen COP15 meetings in December 2009. The `Future Climate' project involves engineering institutions from across the world are generating national technology based climate plans for the period up to 2050. A new report is planned for Q2 2011.

The overall objective of the `Future Climate' project is to contain the maximum global average temperature rise to within 2°C by reducing global GHG emissions by 50% which translates to 80% for developed nations. The plan is actually set to target 90% emissions cut relative to 1990 in order to reflect a degree of overplanning and overdesign that is necessary in risk management to ensure implementation is robust enough for the project target of 80% to be met.

The plan is summarised in the Action Plan Roadmap in Appendix A of the report.

2. Model / scenario description

a) timespan and region	UK primary energy demand and supply in 2050.
b) scenario type	Backcast; Quantitative; Normative; Expert and Whole System.
c) what the approach has been designed to achieve	Meeting the 80% CO_2 reductions within the mathematical bounds of technology capabilities (i.e. The MacKay approach) Provides an itemised action plan of what is required to meet 80% emissions reductions under a particular scenario. A cross-industry consensus plan.
d) description of modelling method	No system modelling or testing of viability of supply portfolio proposed (i.e. scenarios may not actually be viable). No granularity of technologies adopted, highly simplified representation of the energy system. No indication of the feasibility of other scenarios over this one - or the drivers that would make this more likley than any other. Partly based on the Mackay Plan C. Evidence based methodology from 3 key texts – David Mackay's Sustainable Energy - without the Hot Air, The Climate Change Committee's Building a Low Carbon Economy - The UK's contributiuon to Tackling Climate Change and DECC's Low Carbon Transition Plan. Working Party (including 4 IMechE Fellows, 1 ICE Fellow, 3 Cambridge professors - 1 now a Chief Scientific Advisor) discussed and brainstormed challenges and convened to collect ideas, structures and data for UK climate plan. Subsequently, designated individuals completed the work with a lead author. Consensus was maintained across the expert working party (eg nuclear v renewables industries). No model was used but looking at creating an action plan to achieve 80% reductions using technology capabilities and developing a scenario to attain this.

e) references, links	Report available from http://www.imeche.org/knowledge/themes/environment/climate-change/copenhagen-conference/uk-2050-energy-plan.

3. Key Assumptions

a) carbon & energy prices	Not specified. Cost not explicitly included as driver for scenario development.
b) final energy demand	UK current total energy consumption based on 125 KWh/day/person based on 60 Mn population at 340 GW.
c) economic conditions	Assumed to be 1-2 % growth per year (within the parameters set by the Bruntland approach to sustainability).
d) social conditions	Population growth is assumed to be similar to 1950-2000 and no mass migration due to rising sea-levels, water shortages and sudden population growths (from other nations).
e) learning rates	Generation technologies considered developed and available though for some technologies it is considered 10 years experience required before realistic data to support investment *e.g.* Wave and Tidal Power.
f) technology costs	Assumptions that fiscal support mechanisms through feed-in tariffs would drive down costs of PV and solar thermal. Appendix A highlights technological advances, incentives and developments needed to facilitate the proposed pathway.
g) policies	Assumes existing UK / EU energy policy with: • 2015 - 50% of UK coal plants closed due to EU Large Combustion Plant Directive; • existing nuclear capacity to be replaced and no cap on new nuclear within 30-35 GW of new investment in electricity generation; and • new coal plant requires 400 MW of CCS fitted by 2015 and on entire output by 2025.

4. Outputs

(a) final energy demand overall;

Energy demand	2030		2050	
	PJ	Reduction on 2006	PJ	Reduction on 2006
Total energy demand	5,530	25	4,320	42
Heat (housing)	1,250	35	950	50
Transport	1,600	36	1,200	52
Industry Processes (incl Energy Sector)	2,650	10	2,150	27
Other (agriculture, forest and fishing)	30	21	20	47

(b) how demands were met by fuel	Switch of primary energy supply from 91% fossil fuel to 69% low carbon or renewable sources. Oil and gas use is cut by 90% by 2050 and coal use is more than halved.

<table>
<tr><td>(c) power generation by technology</td><td>Developing and using CCS for all large scale fossil fuel power generation and fossil fuel intensive process plant such as steel and cement. The role of CCS or some alternative technology in achieving global GHG reduction considered to be the most crucial technology due to the widespread availability of cheap coal and role in key nations energy generation capacity.

<table>
<tr><th>Capacity (GW)</th><th>2030</th><th>2050</th></tr>
<tr><td>Nuclear[1]</td><td>20</td><td>25</td></tr>
<tr><td>Coal[1]</td><td>17</td><td>1</td></tr>
<tr><td>Gas[1]</td><td>13</td><td>5</td></tr>
<tr><td>Biomass</td><td>9</td><td>12</td></tr>
<tr><td>Wind</td><td>27</td><td>40</td></tr>
<tr><td>Solar PV and Heat</td><td>3</td><td>9</td></tr>
<tr><td>Wave and Tidal</td><td>6</td><td>11</td></tr>
<tr><td>Waste</td><td>6</td><td>3</td></tr>
<tr><td>Hydro</td><td>1</td><td>1</td></tr>
<tr><td>Net imports</td><td>3</td><td>10</td></tr>
</table>
[1] need to be developed to be close to zero emissions

Assumes that utilisation for fossil and nuclear plant is 0.8 and load factor for wind is 0.3.

Decrease in contribution from waste based on successful implementation of reduction strategies (less packaging, more recycling etc) which reduces the volume of material.</td></tr>
<tr><td>(d) role for bioenergy</td><td>Suggests that at a country district level biomass fuel may be easily available and a village wide biomass heating network can be constructed at reasonable cost.</td></tr>
<tr><td>(e) role of enabling technologies</td><td>Increased pumped hydro and other electricity storage capacity needed to cope with the inherently greater intermitency of renewable sources (upto 10GW capacity may be needed by 2050). High Voltage DC grid connections to other EU countries will be significant in allowing better management of the grid. This is on top of the significant improvements required to UK National Electricity Grid to manage supply side intermittency and increased resilience to storms and climatic causes of power outages.</td></tr>
<tr><td>(f) extent of decentralised energy production and role of CHP</td><td>Suggests that at a country district level biomass fuel may be easily available and a village wide biomass heating network can be constructed at reasonable cost. Towns may use waste as a source of both electrical power and heating. Considered that these smaller local plants can achieve high overall efficiency by supplying a mix of electrical power, heat and recovered materials.

For older homes, fuel cell CHP for low density areas and district heating CHP for high density areas considered a viable interim solution whilst the grid is insufficiently decarbonised enough to justify air source heat pumps.</td></tr>
<tr><td>(g) costs of achieving goals</td><td>Based on the Committee on Climate Change as per the Stern Review of the order of 1% of GDP. Within this, the report emphasises the need for appropriate targeting of incentives.</td></tr>
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5 Key messages

- UK total primary energy supply should reduce by 42% by 2050 compared to 2006 and remaining supply being transitioned to zero or low carbon technologies to achieve a 90% reduction in UK GHG emissions relative to 1990 levels (i.e. remaining demand supplied through low / zero carbon technologies).
- Reduction in primary energy supply made possible through: Improving vehicle efficiency, modal shift from road and short hall air to rail and sea, significantly reducing (space) heating demand, improvement in building electrical systems, improving power generation efficiency especially to capture heat and power, reducing energy consumption in industry and encouraging local food production for local people to reduce processing and transport.
- Key programmes underway to faciliate targets include Carbon Capture and Storage, Electric Vehicles and Building Energy Efficiency Improvement.

Desired outcomes from the plan:

- Major investment to improve the electricity distribution grid, set up local heating networks, and encourage new clean energy sources ;
- Training of skilled engineering sector employees for the new economy ;
- Public engagement to drive change in food, heating and transport expectations;
- Supporting key programmes of work to enable new technologies;
- Availability of Government incentives and agile policy to meet the continuously changing needs of this complex programme;
- Major business opportunities flowing from the new technologies needed; and
- Nuclear new build now is replaced in 2050 by renewables or fusion.

Electricity Generation:
Switch of primary energy supply from 91% fossil fuel to 69% low carbon or renewable sources. Some centralised plant buring gas is retained to provide system flexibility. Majority of flexibility comes from European interconnections allowing import of concentrated solar from North Africa and export of excess wind. Significant penetration of wind and nuclear.

Transport:
Significant improvements in the efficiency of IC engines and hybrid cars result in a reductions in emissions augmented by use of light weight materials, improved aerodynamics and tyre technology such that by 2015 motorists switch to `best-in-class' models. Electrification of road transport gathers pace from 2015, and significant roll out implemented by 2030 (vehicles using liquid fuels do so using high blend biofuels). Transport energy use halved by 2050 as modal shift to sea and rail improves efficiency. Demand for air travel significantly reduced by 2030.

Energy Efficiency and Heat
Most heat demand met by heat pumps or disctric heating by 2030. Efficiency in housing sector means energy demand in buildings has dropped by 50% in 2050.

Mark Workman, ERP Analysis Team
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