National Grid, 'Gone Green' (2009)

1. Purpose of the activity

Following the Governments publication of its consultation on a UK Renewable Energy Strategy the Electricity Networks Strategy Group (ENSG[1]) formed a Project Working Group to:

- Develop electricity generation and demand scenarios consistent with the EU target for 15% of the UK's energy to be produced from renewable sources by 2020; and
- Identify and evaluate a range of potential electricity transmission network solutions that would be required to accommodate these scenarios.

In order to fulfil these objectives, a number of electricity demand backgrounds were developed, within which, a number of factors have been taken into account including renewable targets; closure of existing plants due to legislation and age; contracted new connections for all types of generation plant; the potential for, and location of onshore and offshore wind generation; and the potential build rates for wind and new nuclear generating capacity.

The fuel mix in the scenario for 2020 was based on the National Grid's `Gone Green' scenario.

The `Gone Green' Scenario assumes that the correct economic incentives are in place to achieve the 2020 EU 15% renewable targets and 2050 80% emissions reductions - it is described below.

2. Model / scenario description

a) Timespan and region	"Broad and shallow" look out to 2050 exploring the implications of the 80% target for the UK electricity and gas networks.
b) Scenario type	Back-casting; Quantitative; Normative; Expert; Sector Specific. Generating a 2050 system which meets the CO_2 constraint. Followed by analysis of changing input constraints on final energy mix.
c) What the approach has been designed to achieve	Cost minimisation of meeting UK energy demand (power, heat and transport) against constraints specified (e.g. limitations on ability to build nuclear generation capacity and ability to electrify vehicles). Noteworthy, that without these constraints the model would choose virtually all nuclear electricty with PHEV for transportation and significant top up gas for heat.
d) Description of modelling method	Least cost optimisation, simple solver, pared down representation of UK energy system. The model is highly simplified and doesn't include any locational element, and model inputs are static assumptions without tehcnology learning factors. Technology mix outcomes highly predicated on cost input assumptions. It is a simple approach which allows demonstration of broad, high-level hypotheses on system evolution.
e) References, links	http://www.ensg.gov.uk/

[1] A cross industry group jointly chaired by DECC and Ofgem.

3. Key Assumptions

Dominant assumptions driving scenario output to 2050.

a) carbon & energy prices	Derived from various publicly available sources. Price for wind around 2x more than CCS and nuclear. Other prices based on current costs though it is acknowledged that as oil is depleted it becomes more energy intensive to extract.
b) final energy demand	
c) economic conditions	
d) social conditions	Population predicted to rise from 60 Mn in 2006, through to 71.1 Mn in 2031 to 787 Mn in 2050 (a 27% increase from 2006 to 2050. This is reflected in the number of households which increases from 25 Mn in 2008 to 35 Mn in 2050 (an increase of 40%).
e) learning rates	No technological learning assumed (except for CCS?)
f) technology costs	
g) policies	

4. Outputs

(a) final energy demand overall;	1623 TWh (gross CV) for 2020
(b) how demands were met by fuel	Fuel mix for 2020 in the `Gone Green' Scenario connected to transmission is (of total 110 GW): Gas: 34.1 % Coal: 19.8 % Nuclear: 6.9 % Wind: 29.1 % - 19 GW offshore and 11 GW onshore Other Renewables: 3.3 % Others: 5.5 % 230 TWh of total UK renewable electricity contribution by 2020 Total offshore wind capacity in England and Wales assumed to be in the region of 21-25 GW by 2020. Two new nuclear installations with combined capacity of 3.3 GW by 2020 with total nuclear capacity at 6.9 GW.
(c) power generation by technology	Some clean coal development is assumed.
(d) role for bioenergy	Biomass 0.8 GW of capacity in the form of bio-methane. Biofuels 38 TWh
(e) role of enabling technologies	Role of interconnectors has a significant role at 4.2 GW capacity.
(f) extent of decentralised energy production and role of CHP	Forecasts shows transmission connected and larger scale embedded generation only. Growth in embedded generation results in 15GW of embedded generation including onsite CHP in 2020.
(g) costs of achieving goals	

5. Key messages

Key conclusions or messages from the scenario / model:

- Full electrification of heat could come at an exceptionally high price without a workable heat storage solution to even out peak loads. Current yearly load duration curve for gas consumption (for heat) is very peaky compared to electricity. Move this demand into electricity as it stands and this will require a signifcant capacity of very low load factor plant (~5x current peak capacity) - this will be prohibitively expensive. This leaves a significant role for distributed gas in providing peaking capacity for heat demand. Though no account of the role of demand response in provision of heat and heat storage is made.
- Significant electrification of heat (or transport) is not practical until the last CCGT is off the system i.e. electrification of these demand is driven by marginal carbon.
- Low wind penetration post 2030 as wind is displacing gas rather than unabated coal. Therefore £/TCO_2 saved increases significantly
- There is a role for new product in provision of local heating. This comes in the form of using heat pump technology sized to 50% of load (improved load factor for heat pump will increase efficiency) and additional boost provided by gas top up (and / or other feed-in sources - e.g. Solar thermal, electric top up etc.)
- Electrification of transport limited to PHEVs - rather than full EVs, any kind of electrification of vehicle fleet depends on controlability of charge time.

Electricity Generation:
By 2050 wind generation reaching the end of its lifespan is not replaced, instead CCS-coal and nuclear are built in preference. Intermittency control dependent on controlability of demand, particularly heat and transport. Vehicle to Grid technology must be viable and the concepts possible if intermittency is to be managed

Transport: (In 2020 total demand stands at 563 TWh)
Electrification of the fleet is possible by 2050, but it requires controlability of charge time to be possible from a network perspective.

Energy Efficiency and Heat (In 2020 total heat demand stands at 661 TWh)
Full electrification of heat will come at a high price if peaks in demand are to be met.