The role of Nuclear in meeting the 2050 climate target

The Nuclear Institute - 24th June 2010

[redacted] – National Grid

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Agenda – Roadmap to 2050

- Energy policy & climate challenge
- Primary energy & emissions
  - Electricity (incl. issues around new nuclear)
  - Transport
  - Heat
- Base Case & sensitivities
- Conclusions

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Climate change key challenges

Targets

15% of all energy to come from renewable sources by 2020

80% reduction in CO2 emissions by 2050

Energy policy objectives

Sustainability

Secure energy supplies

Affordability

The challenge is to meet all the targets and the policy objectives simultaneously, in a timely way

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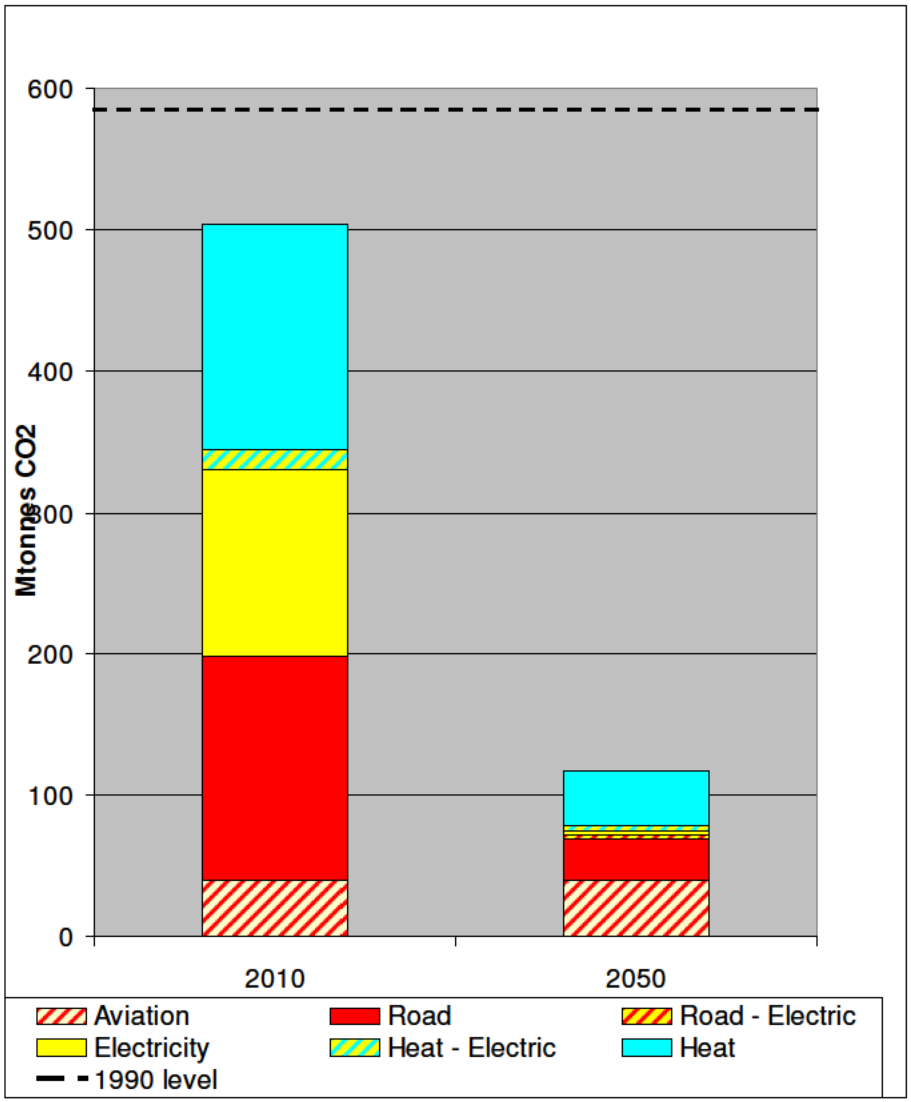
Emissions by sector



- Aim is to reduce emissions from 505M tonnes to 118M tonnes
- Aviation emissions remain the same (40M tonnes) due to difficulty in replacing jet fuel with low carbon sources.
- All sectors emissions greater than 118M tonnes – need to take action on all.
- Emissions for all other sources reduced from 465M tonnes to 78M tonnes
- Some consumption reduction is assumed but can hit target if don't reduced consumption – but at additional cost

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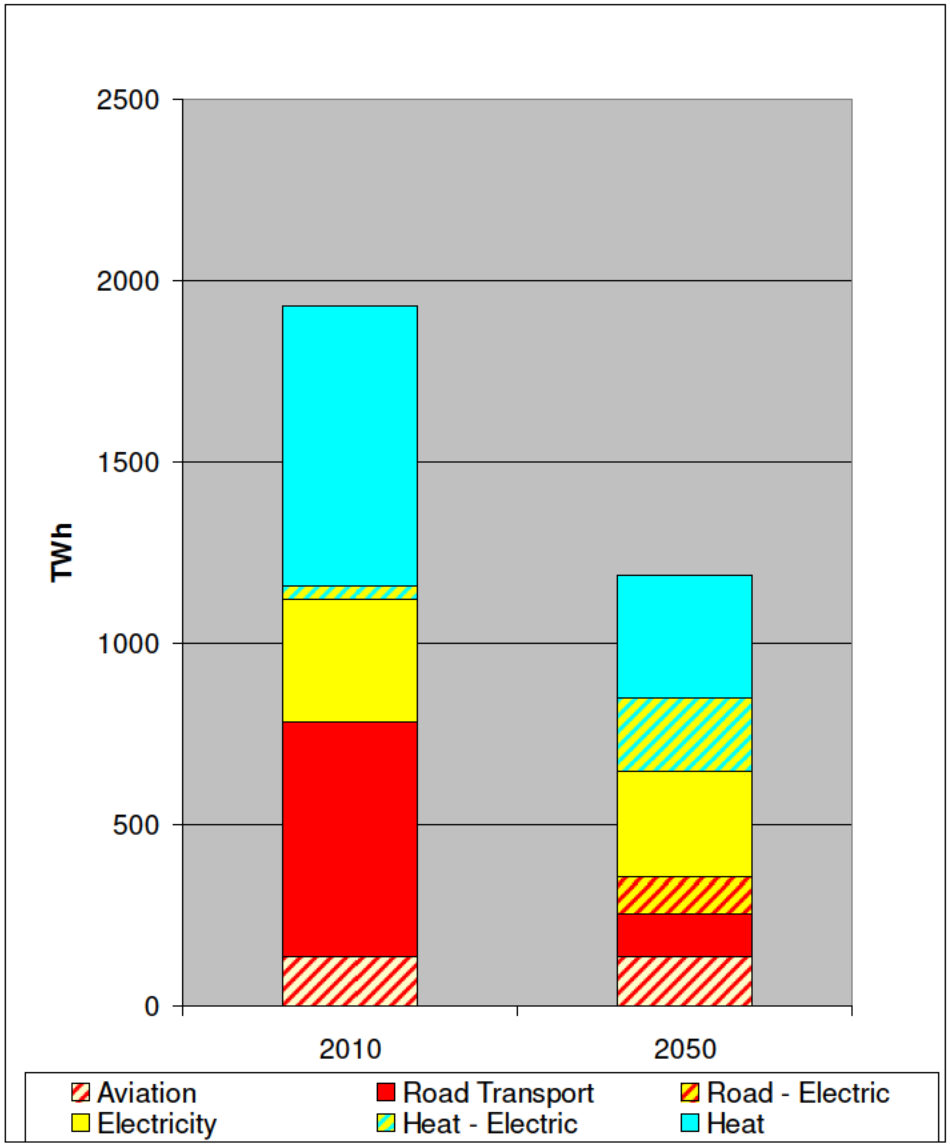
Energy consumption by sector



- Consumption is reduced using the following measures
  - Heat
    - Insulation
    - Increased boiler efficiency
    - Use of Heat Pumps
  - Electric
    - Low energy lighting
    - A-rated appliances
  - Transport
    - Hybrids delivering greater efficiency
    - Batteries delivering further efficiencies

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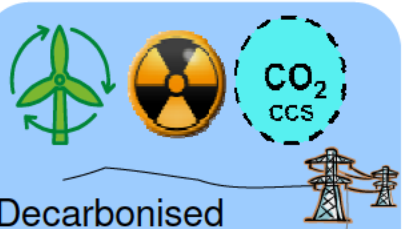
We need decarbonisation across all sectors…

	Electricity	Heat	Transport
Simple efficiency measures across all sectors	 Appliance efficiency	 Insulate homes	 Efficient engines and integrated transport
Decarbonised electricity fuels zero emission vehicles	 Decarbonised electricity…	 Heat pump Mainly for new homes	 and decarbonise transport
Decarbonise gas using biomethane		 Biomethane	 CNG

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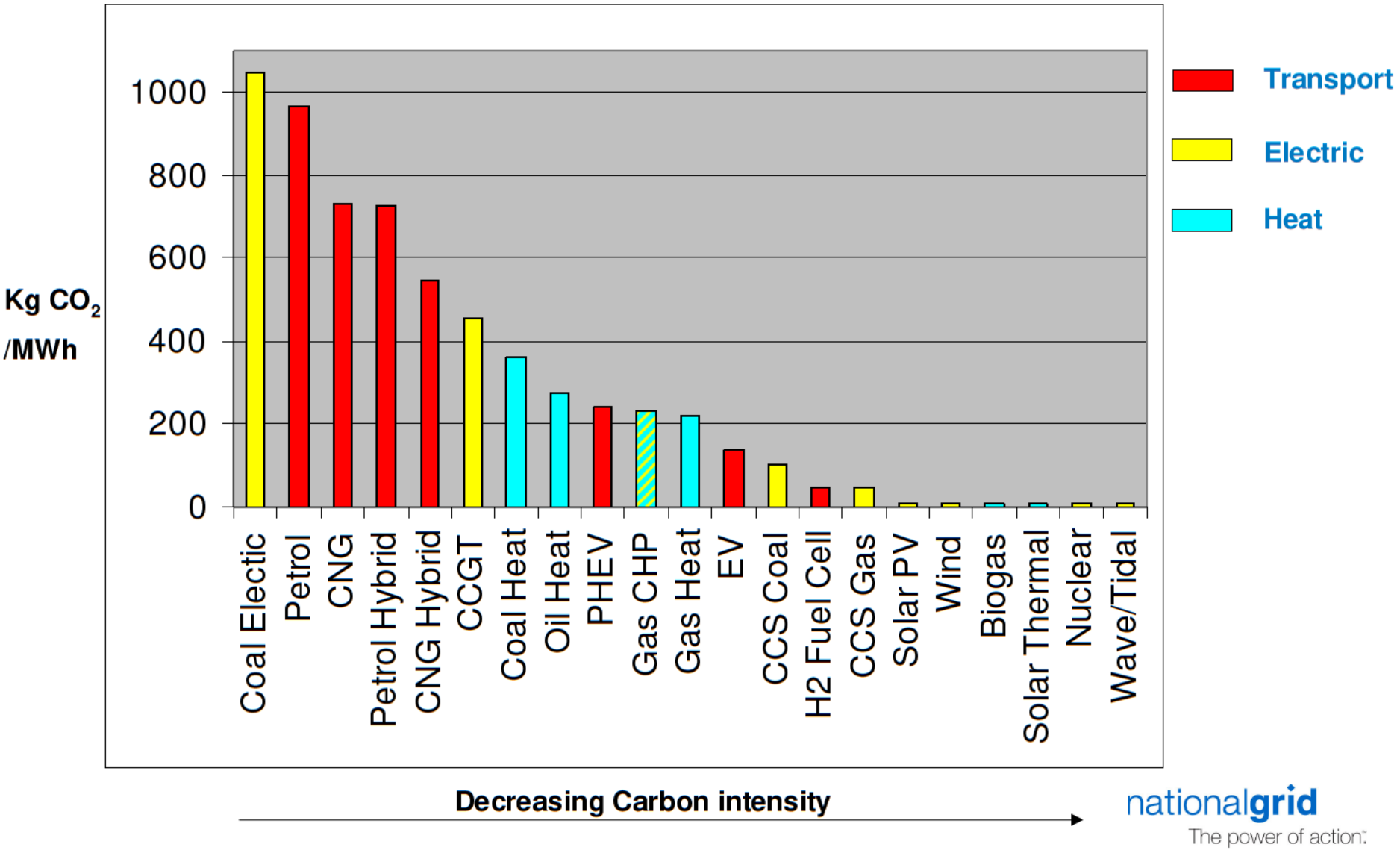
2050 – Overview of approach

- Model works on Carbon optimisation with highest CO2 sources being displaced first
  - Coal and CCGT replaced by Renewable, CCS and Nuclear
  - Coal and Oil heating being replaced by Gas, Biogas and Electricity where suitable
  - Petrol Transport being replaced by Plug in Hybrids and EVs for most transport and Hybrids where electrification not suitable.
- Supply chain constraint limits
  - i.e Nuclear at 30GW
- Cost optimisation also carried out to provide best economic solution for meeting CO_2 targets
  - Prevents power station being run at low load factors (i.e for peak heat demand during winter)
  - Least cost-effective method of Carbon mitigation used as last resort

Carbon intensity matrix



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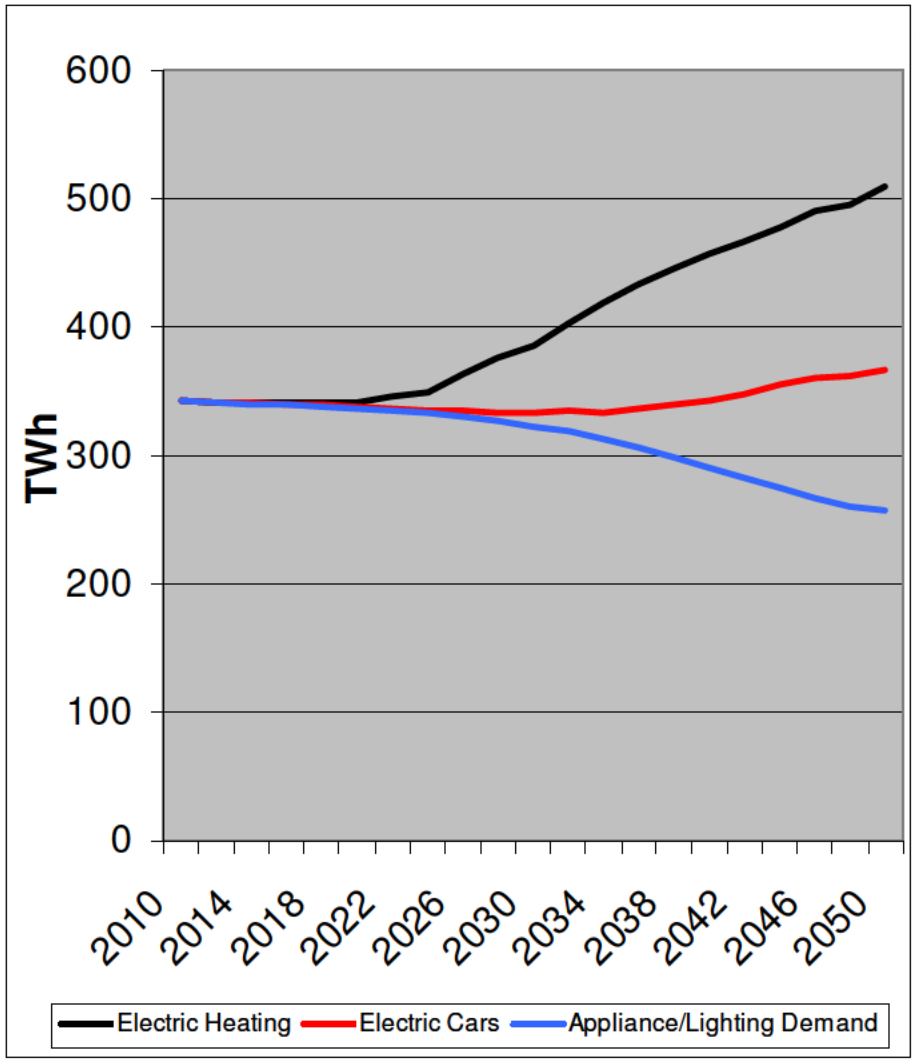
Energy Consumption - Electricity



- Decline (25%) in uses for traditional electric appliances from
  - Use of low energy/LED lighting
  - Improve appliance efficiency
- Full roll-out of electric transport from late 2020s as
  - Spare low-carbon electricity is available
  - Electric car battery issues/costs are resolved
- Spare Low–Carbon electricity used for both heat and electric purposes for future planning despite electrification of transport giving larger emissions reductions

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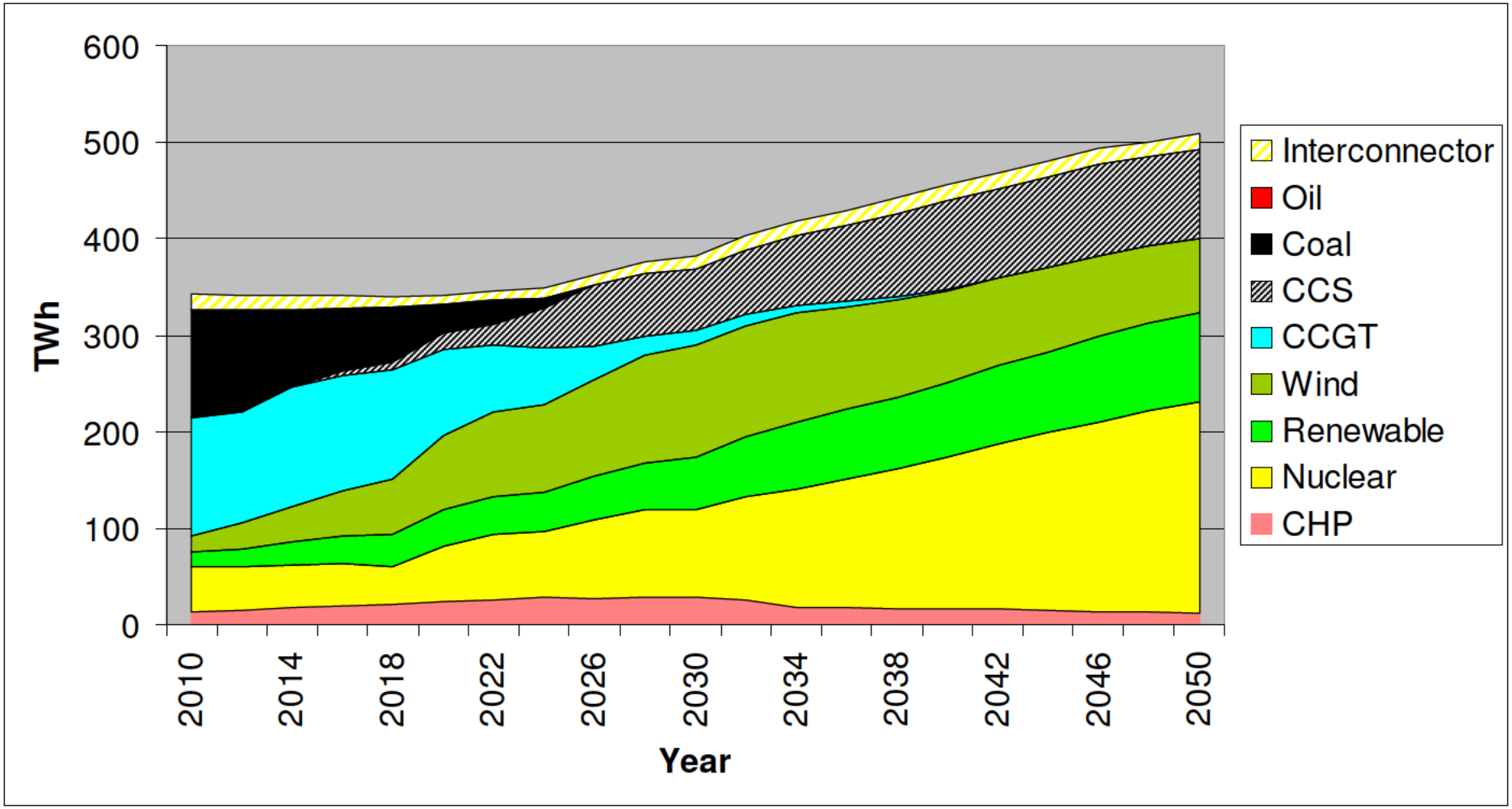
Electricity Generation Mix 2010-2050



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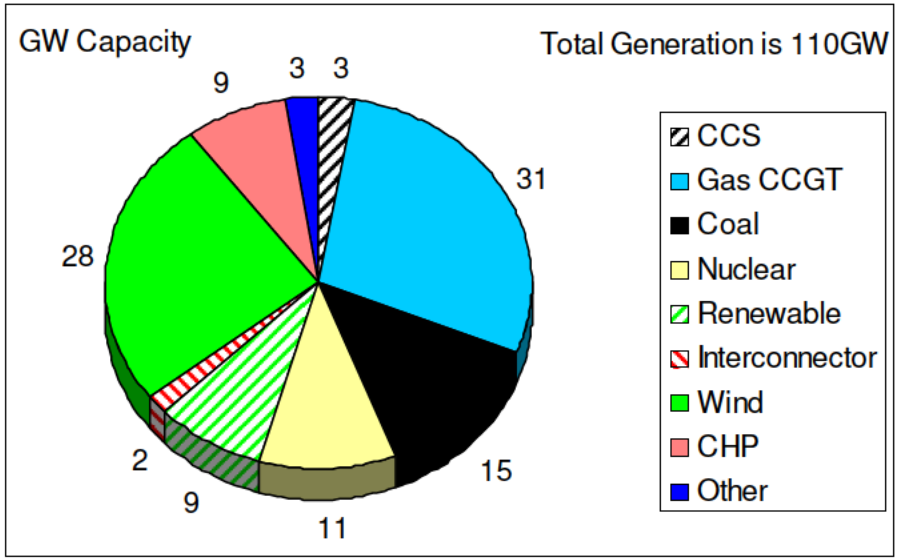
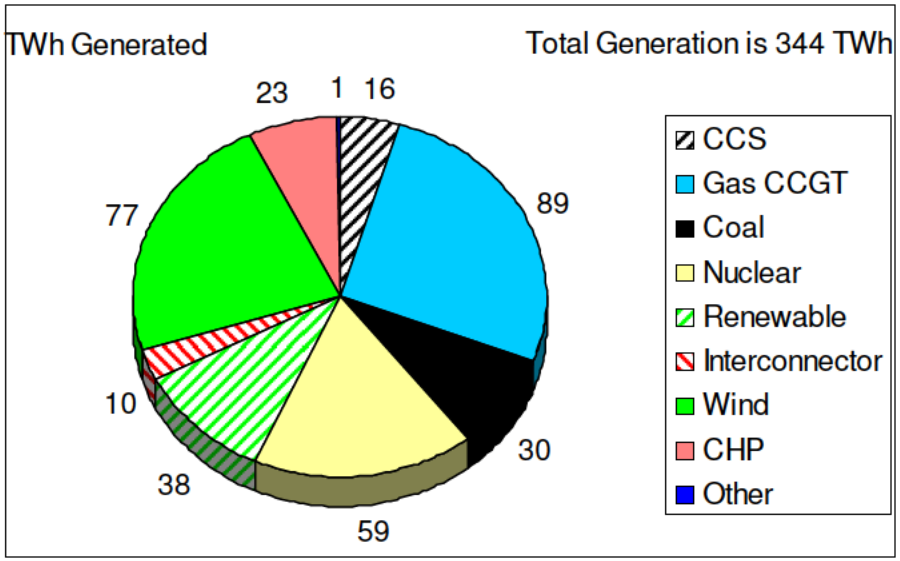
Electricity Supply - 2020





- Stations are run in order of Carbon intensity
- 28GW of wind on system
- Small amounts of other renewable (hydro, tidal, biomass)
- New nuclear build after retirements allow for 11GW of nuclear generation (2.5GW retired, 2.8GW new build by 2020)
- Demonstration CCS Coal plants supplying 2.4GW in total
- Large amount of unabated coal still available but run at low load factors for low wind, high demand conditions
- Interconnector refers to assumed import levels, floating interconnectors are excluded.

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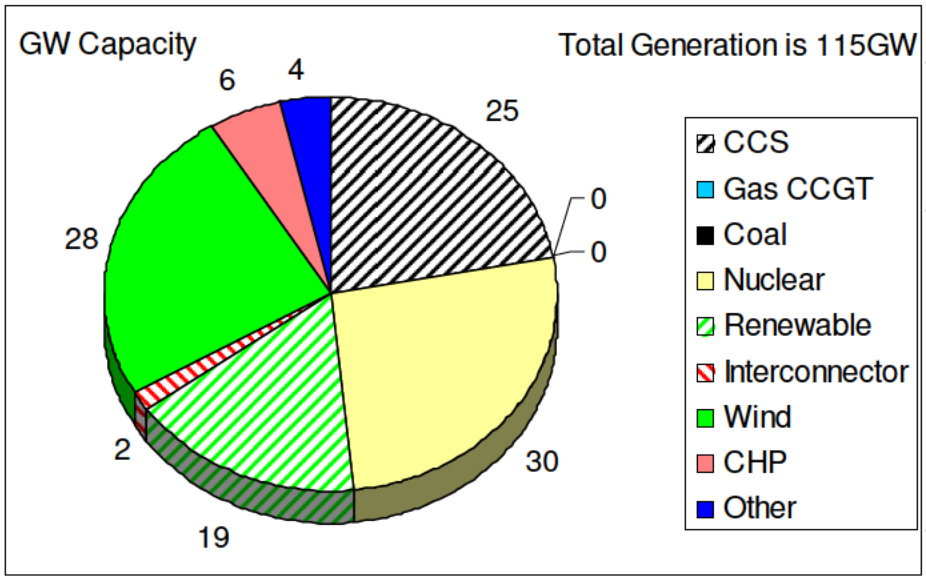
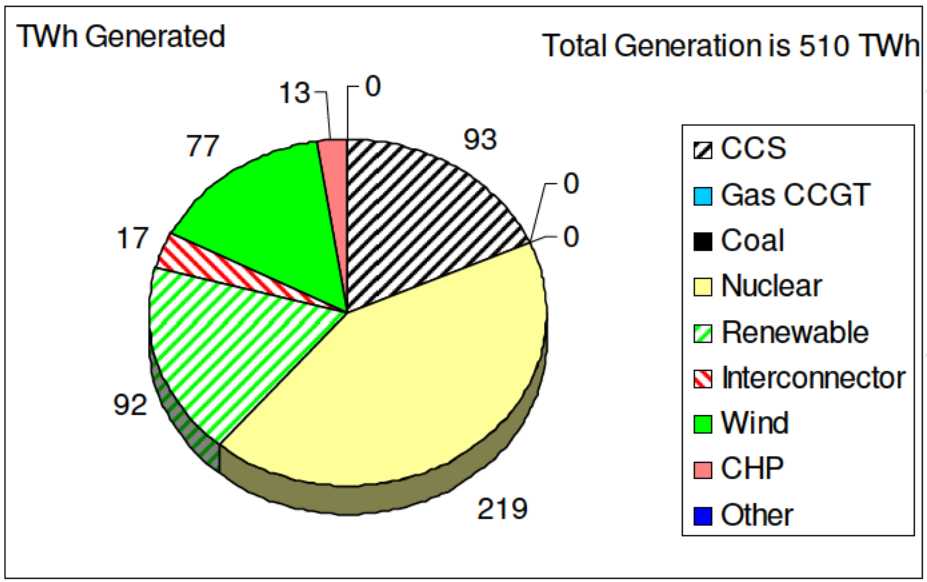
Electricity Supply - 2050





- Increase in CCS generation – operates at load factor of 50%
- Large increase in nuclear generation to 30GW – replanting all existing sites to maximum capacity and a small number of new sites
- Some wind is not replanted due to economic viability without subsidy
- Increases in electric generation used for heating homes and in transport (roll out of electric cars largely complete by mid 2040s)
- Approx 15GW of interconnection capacity is available to allow for different amounts of renewable generation

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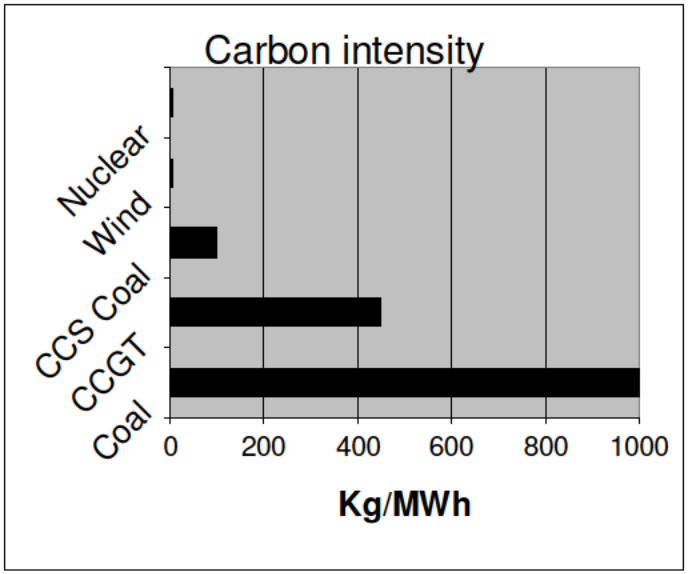
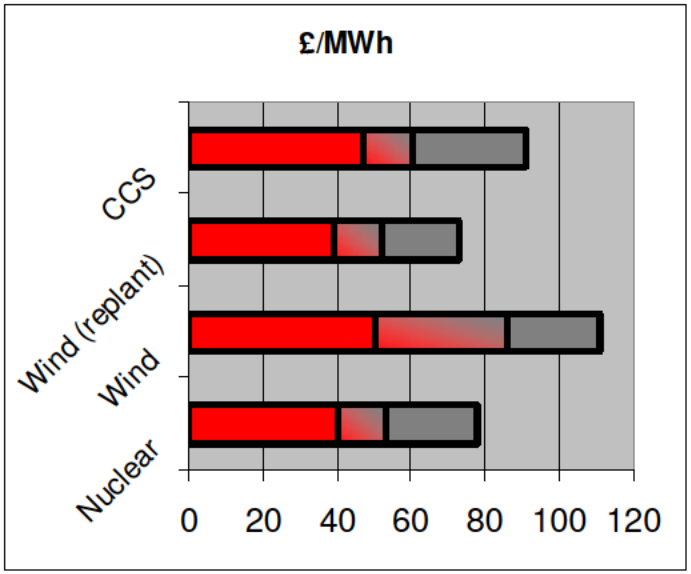
Electricity generation mix rationale





- High Carbon generation replaced with low Carbon Sources
- Nuclear first as cheaper and near zero emissions
- CCS next most economic but limited by 2050 Carbon limit
- Wind used substantially in early years as CCS not commercial and long timescales for nuclear – hits 2020 renewable target
- Only replanted where economic to do so.
- Sensitivities to Base case exist for low/high nuclear cases and when CCS isn't viable.

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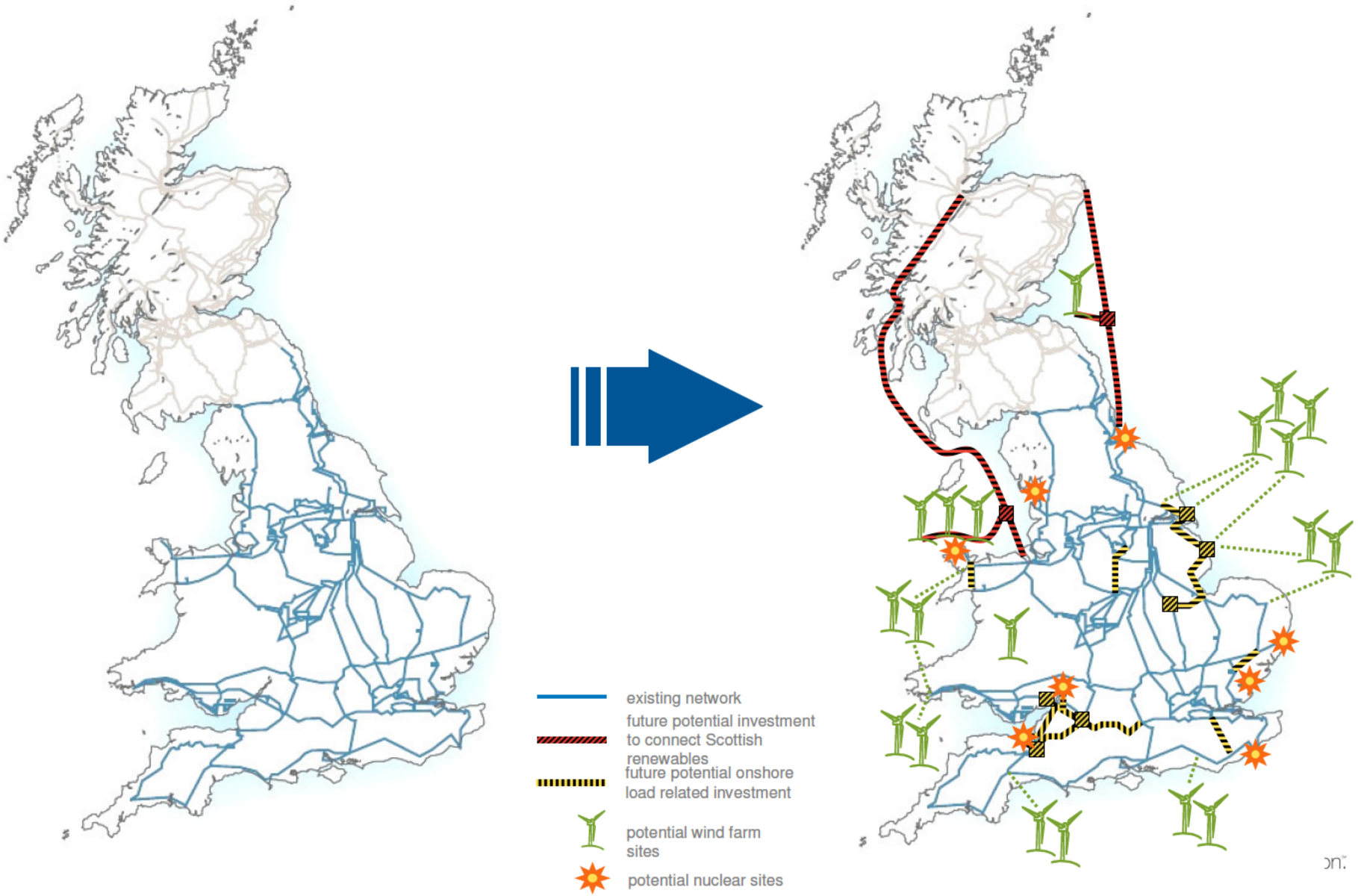
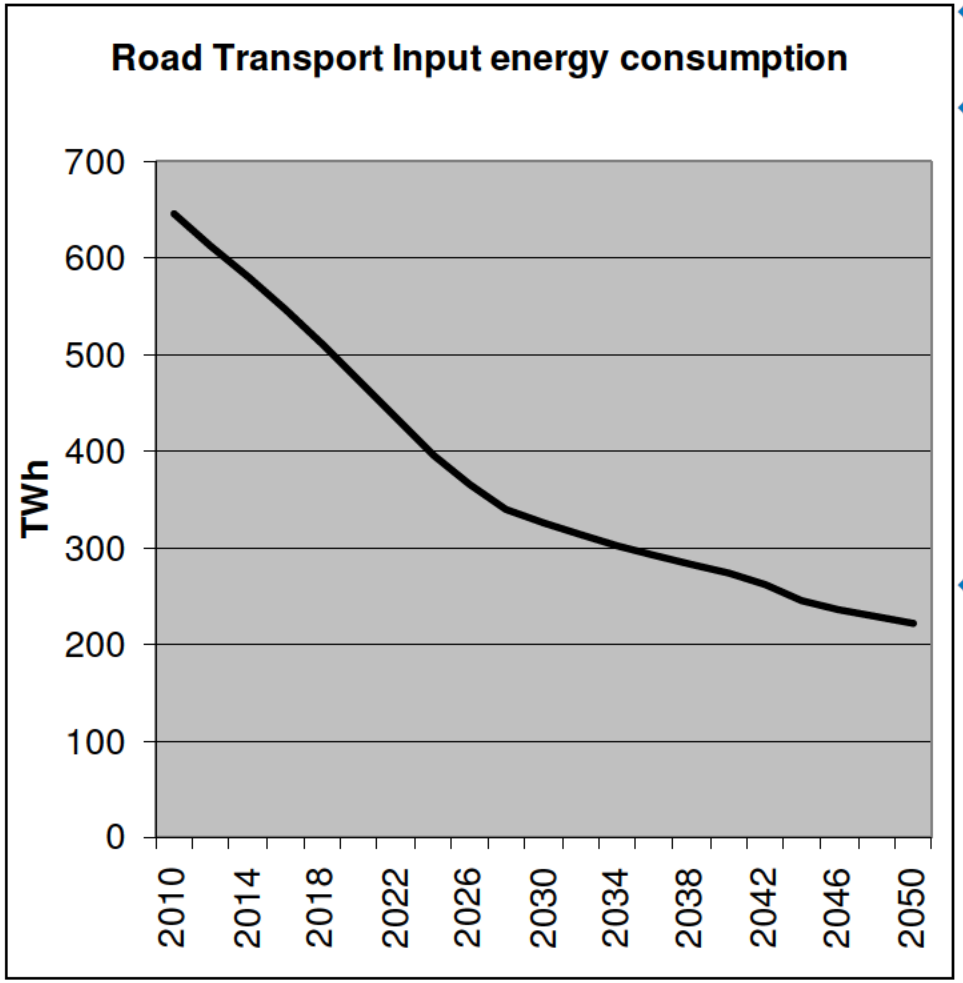
The network challenge: electricity transmission



Issues around new nuclear

- Planning
  - Station design & consents
  - OHL consents
- Capital cost
  - Current overruns
  - Learning rates
- Operational cost
  - Maintenance
  - Uranium cost
  - Waste
- Supply chain
  - Significant new build around the world

Road Transport: Consumption in Base case



- Total miles driven remains flat
- Reduction in energy due to efficiency gains (tank to wheel)
  - Average current petrol engine (25%)
  - CNG/Petrol Hybrid (40%)
  - Electric powered (70%)
- Some vehicles are unsuited for electrifying
  - HGVs (20% of road transport energy), Hybrids can be used instead

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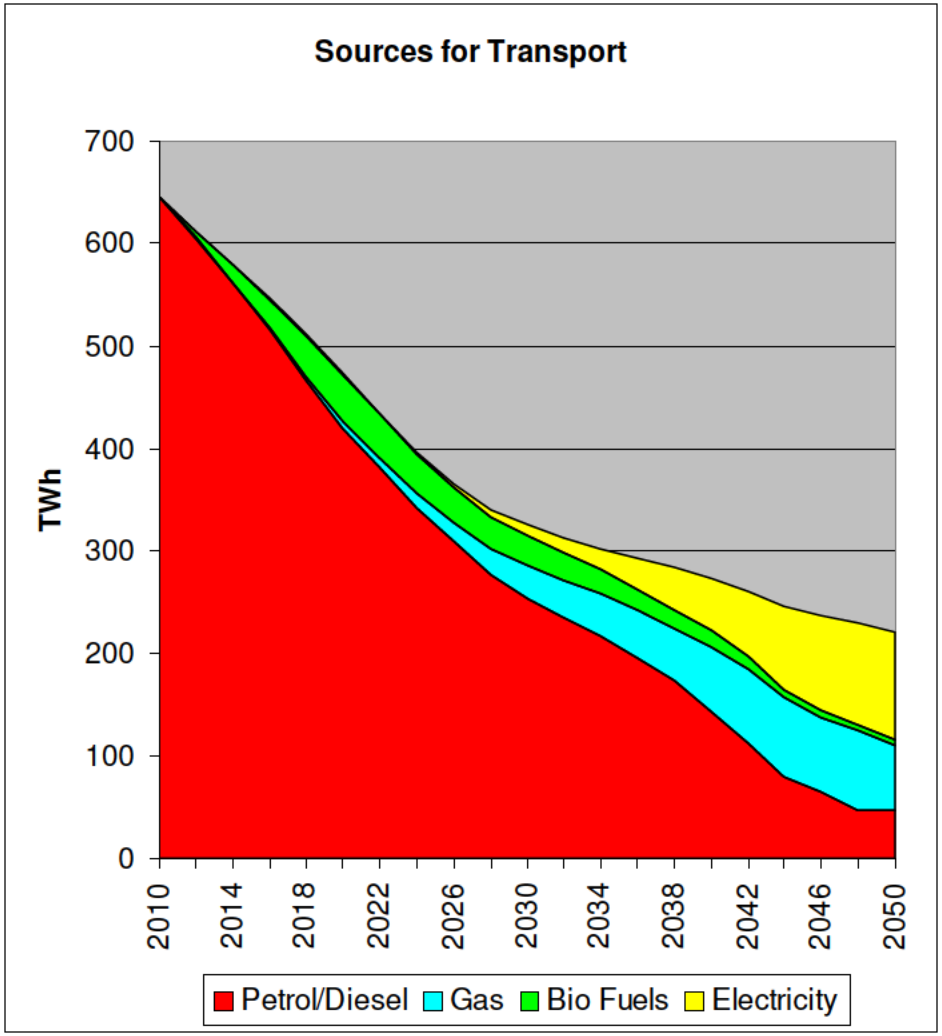
Road Transport: Fuel Supply 2010-2050



- Fossil fuel consumption declines with energy consumption
- Greater use of biofuels provides 10% of energy requirements for Petrol vehicles
- From late 2020's electric vehicles price/capacity developed enough to make commercially viable
- Petrol/CNG Hybrids provide fuel for HGV's
- CNG vehicles marginally more expensive than Petrol but deliver carbon savings

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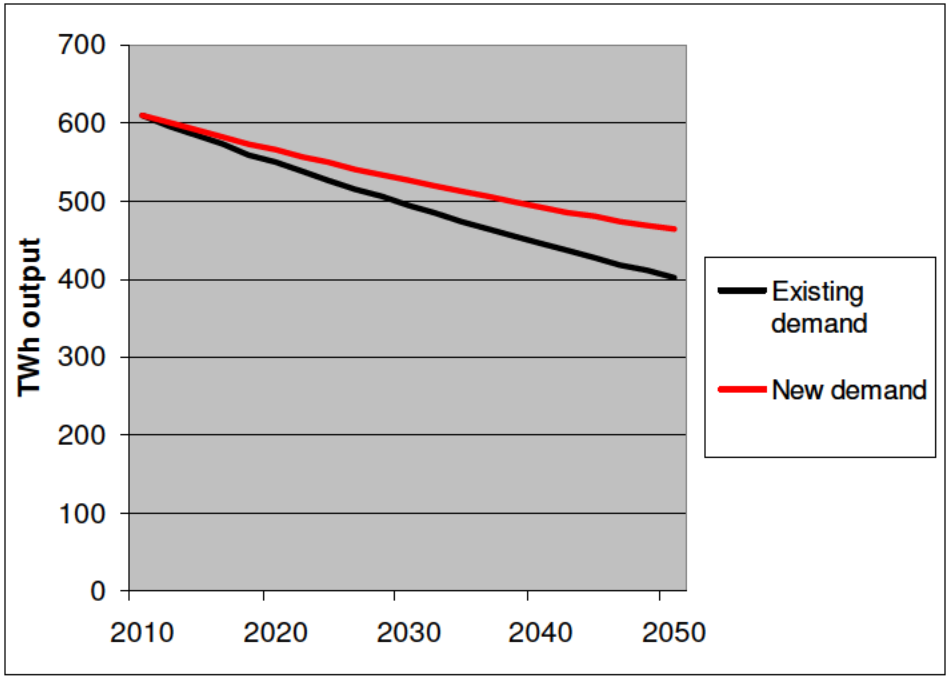
Heat: Consumption – Base Case



- Energy usage in existing buildings drops by a third due to improvements in insulation and turning down of thermostats
- 10 million well insulated new homes require additional 60 TWh of energy by 2050
- Overall reduction in heat output (existing and new stock) of 25%
- Boiler improvements and use of heat pumps reduce the amount of input energy required, hence an overall decrease in input energy of around 34%

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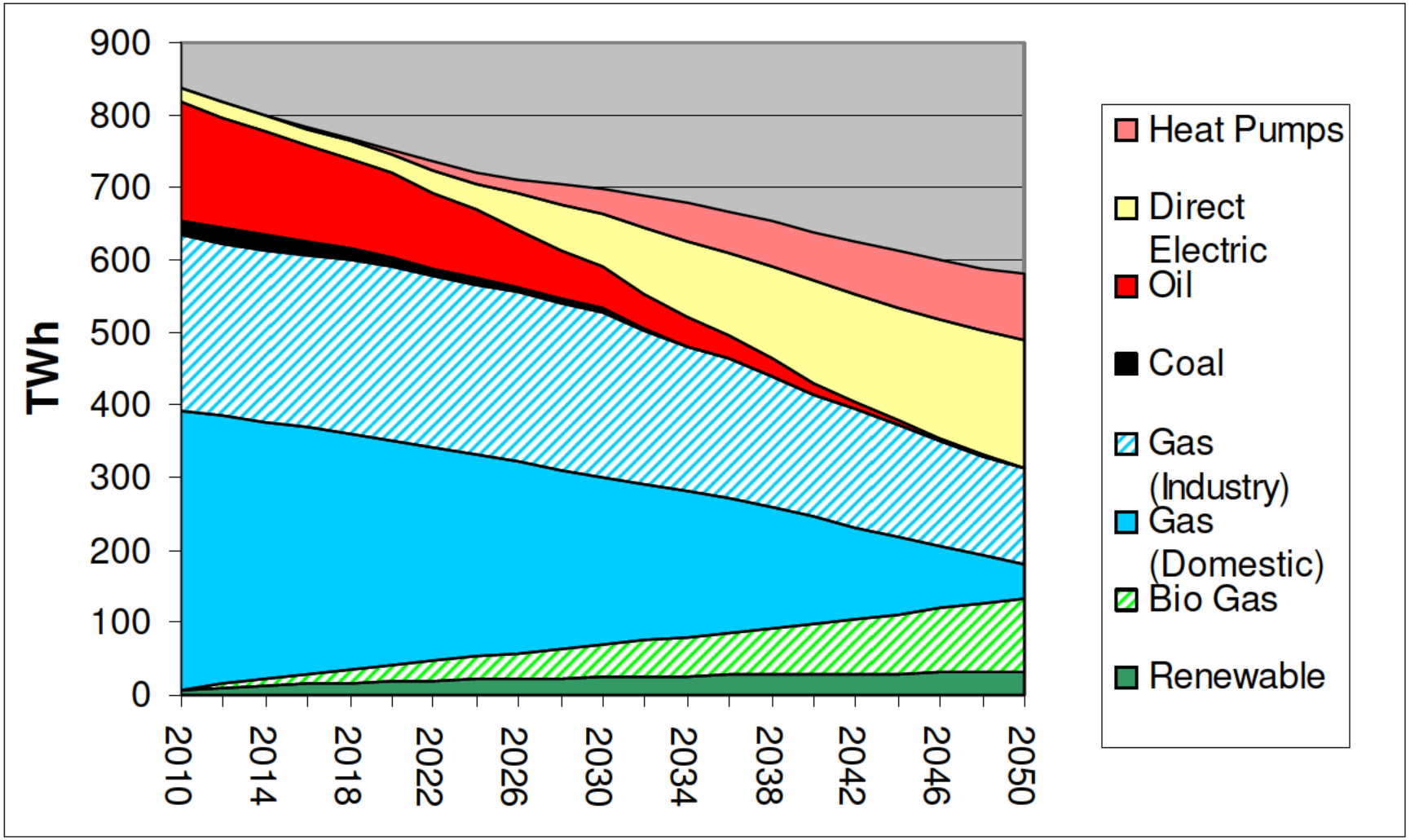
Heat Annual supply 2010-2050



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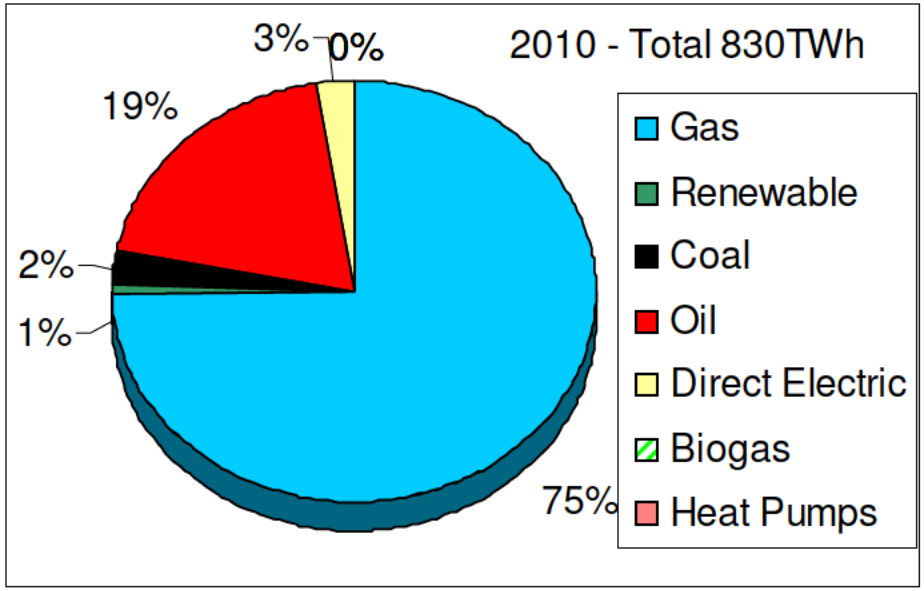
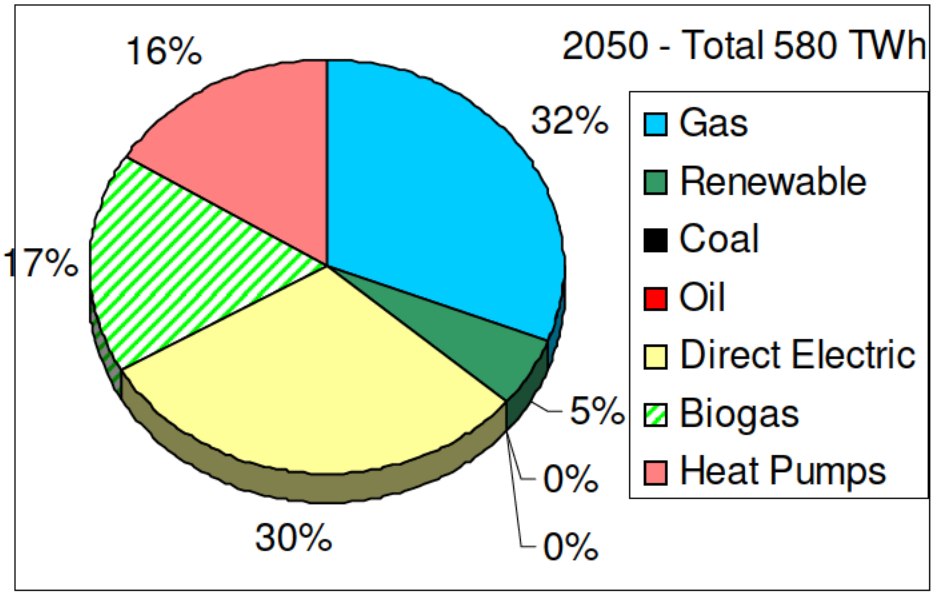
Heat: Supply – Base Case





- Oil and Coal use eliminated
  - Replaced mainly by electric although gas network can expand
- Increased use of electric heating as carbon intensity of electric drops below gas
- Increased use of Biogas
  - 100 TWh in base case
- Increased use of Solar Thermal and wood/biomass.
- Majority of fossil gas is used in high temperature industrial processes

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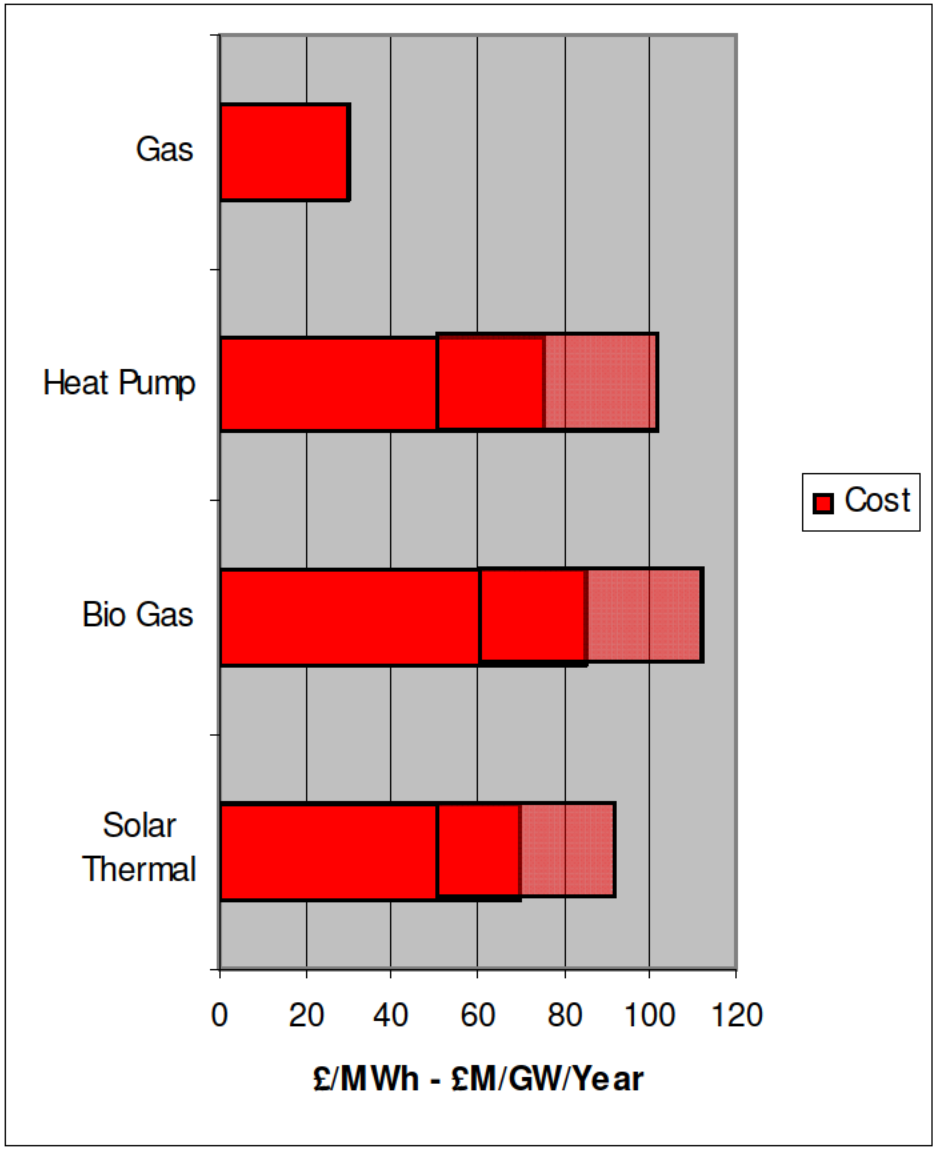
Future heating options and costs



- Gas is cheapest fuel but also has highest Carbon intensity (235kg/MWh)
- Heat Pumps require investment in networks and power stations – Carbon emissions depend upon source of electricity
- Solar Thermals deliver little heat on coldest days
- Biogas and gas can be stored to deliver heat at high demand times.
- Direct low-carbon electricity can also be used – cost and emissions are dependant on power plant.

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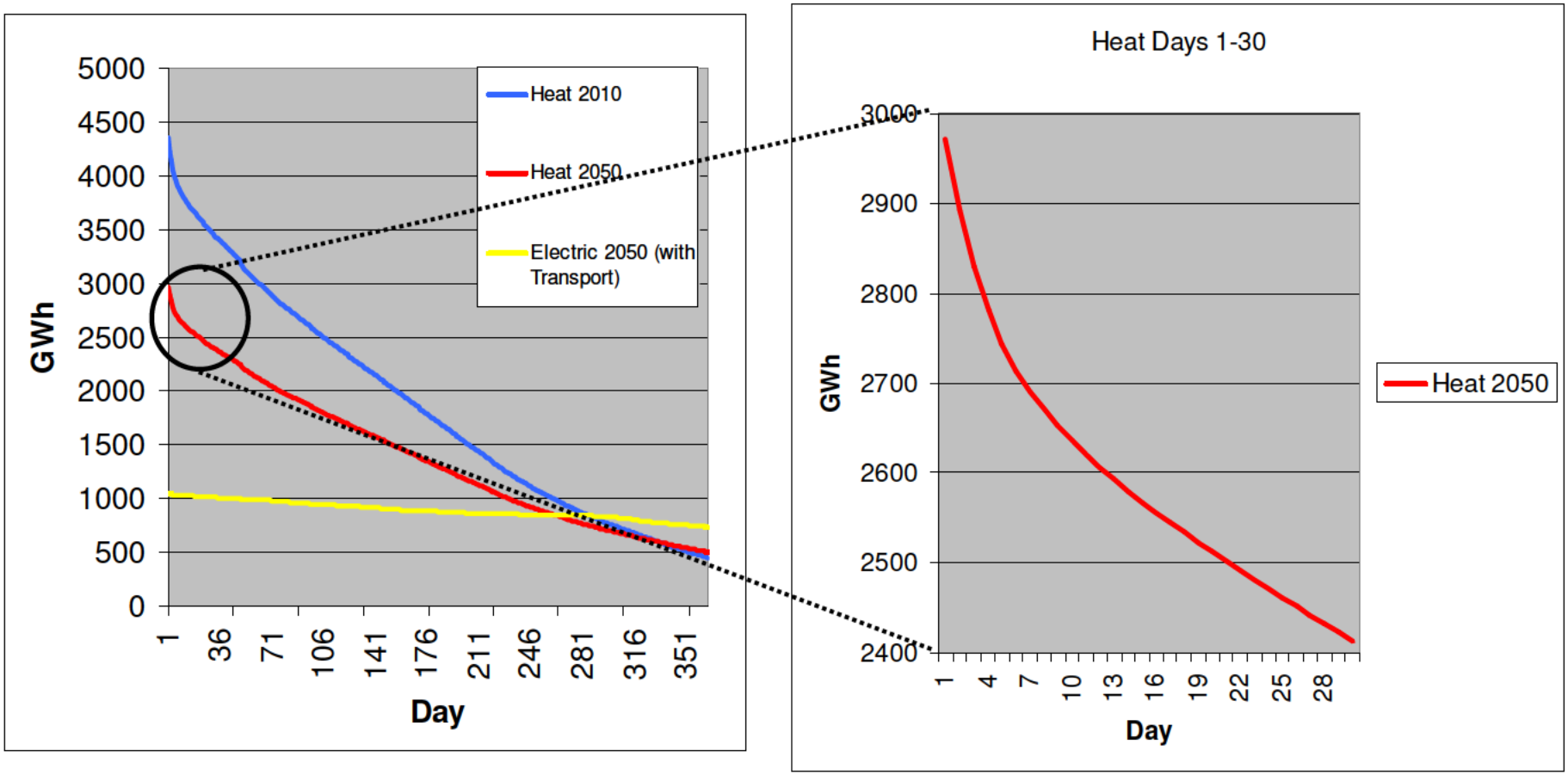
Heat curve flattens with improved insulation but still peaky compared with electric



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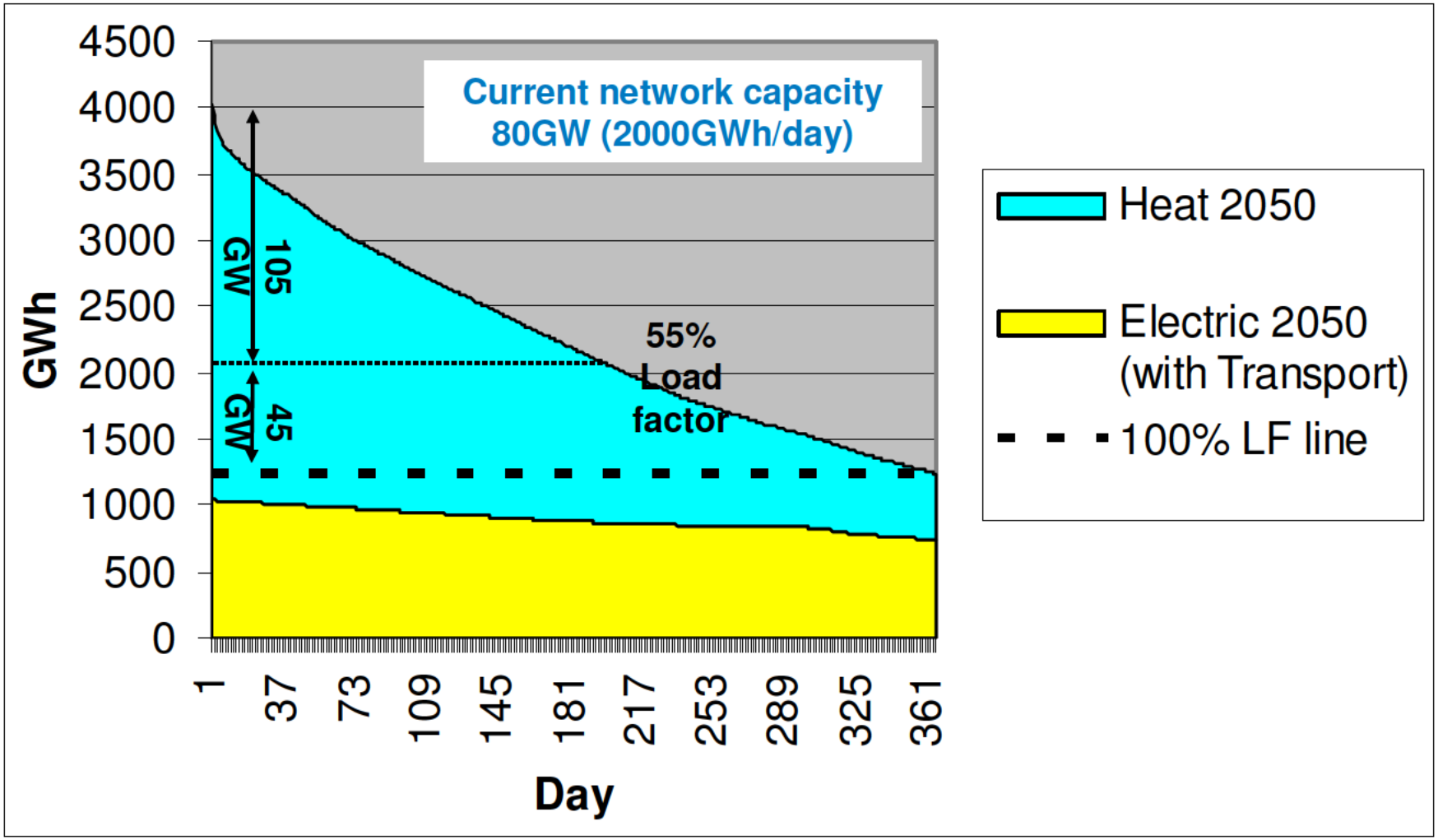
Combined electric and heat daily load duration curves



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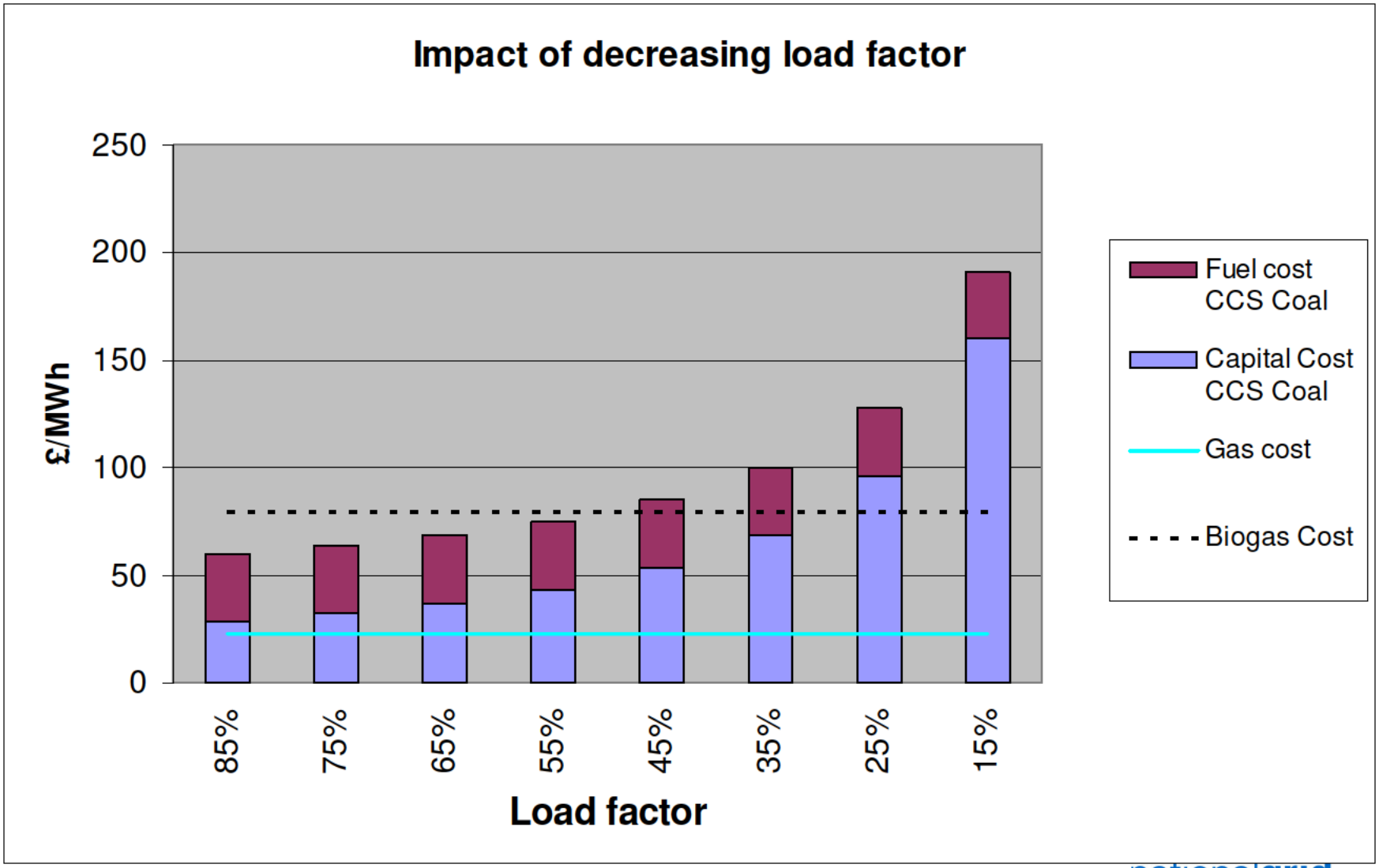
Economics of heating using Biogas/CCS or Gas



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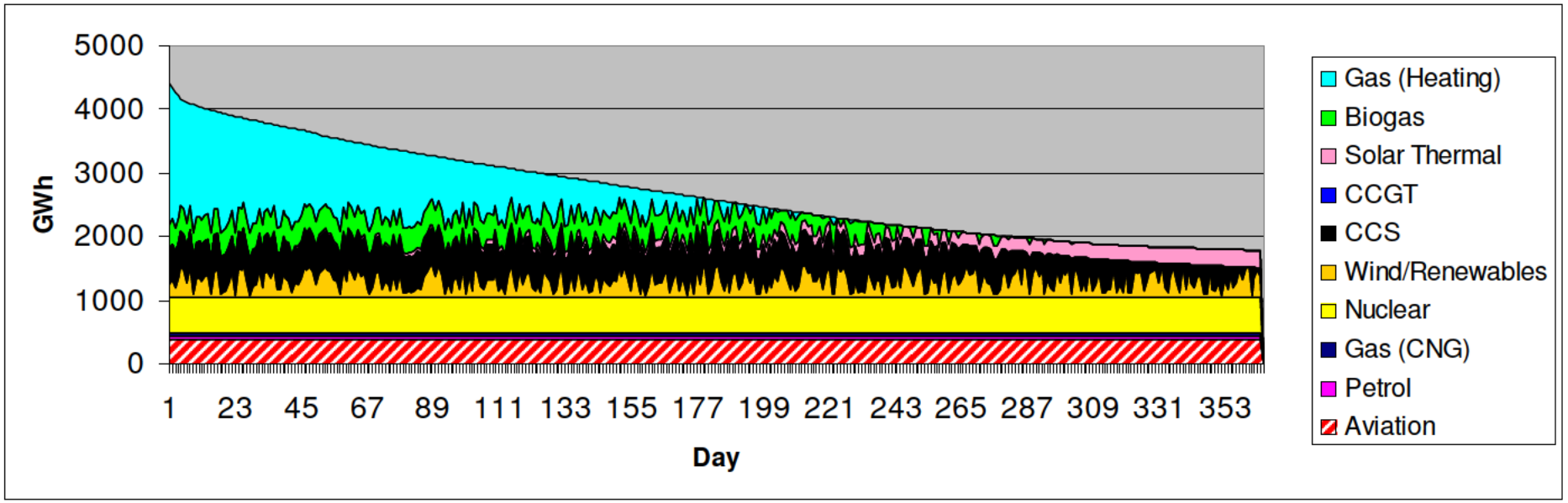
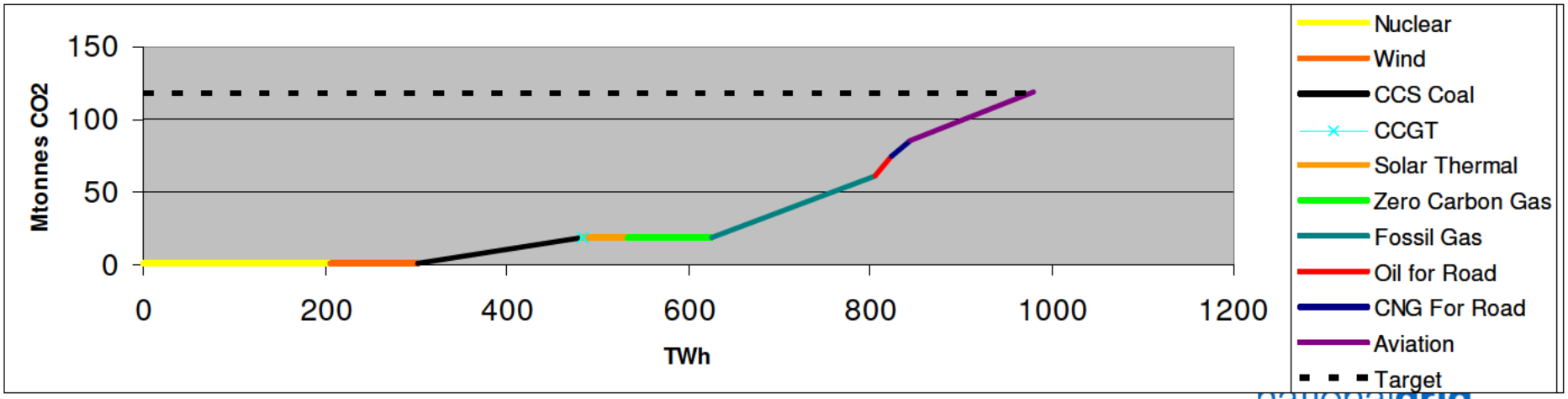
Energy demand and carbon emissions in 2050





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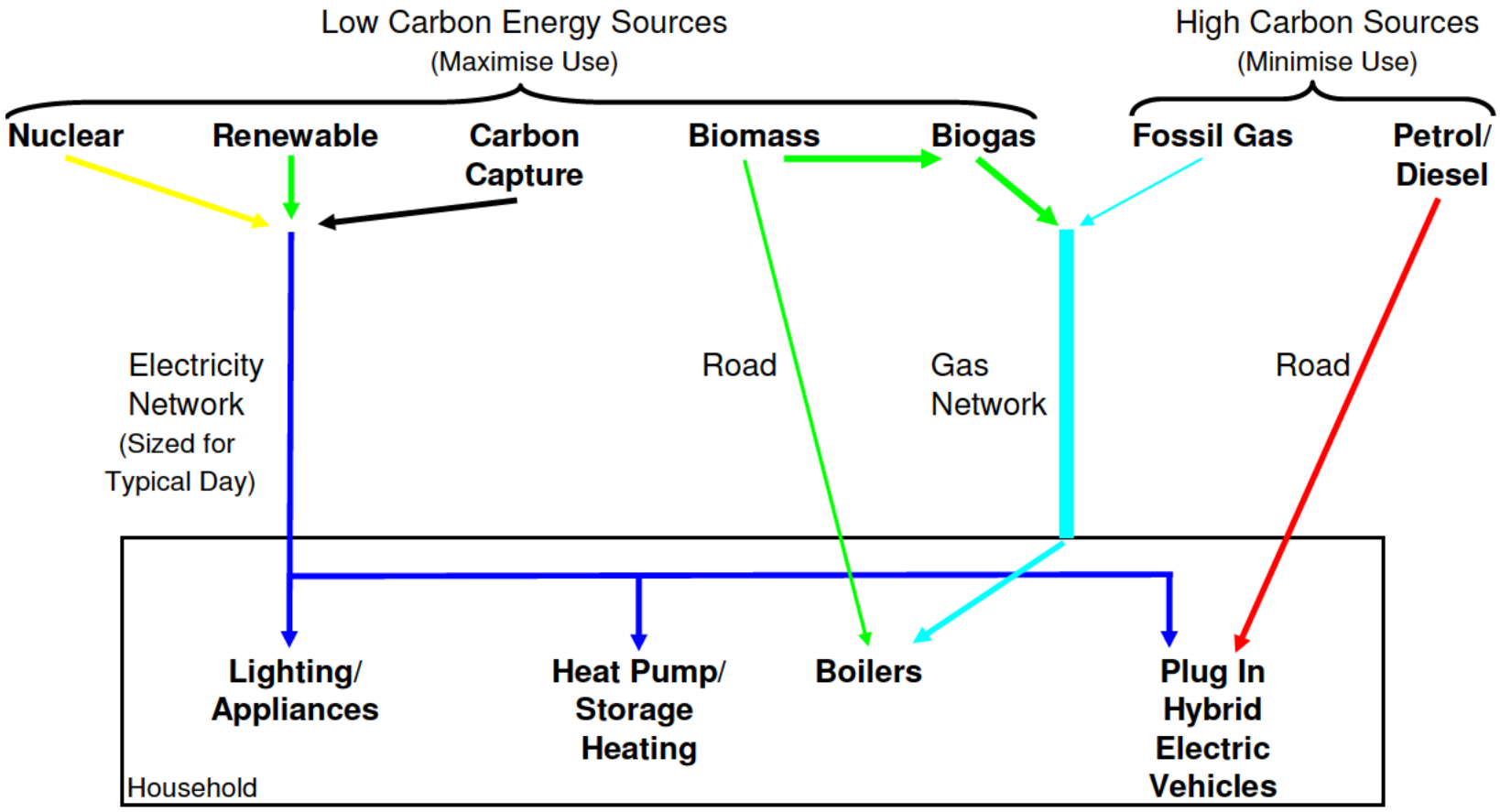
2050 – Average Day



Smart Grid manages interaction between electric and gas demand along with wind intermittency

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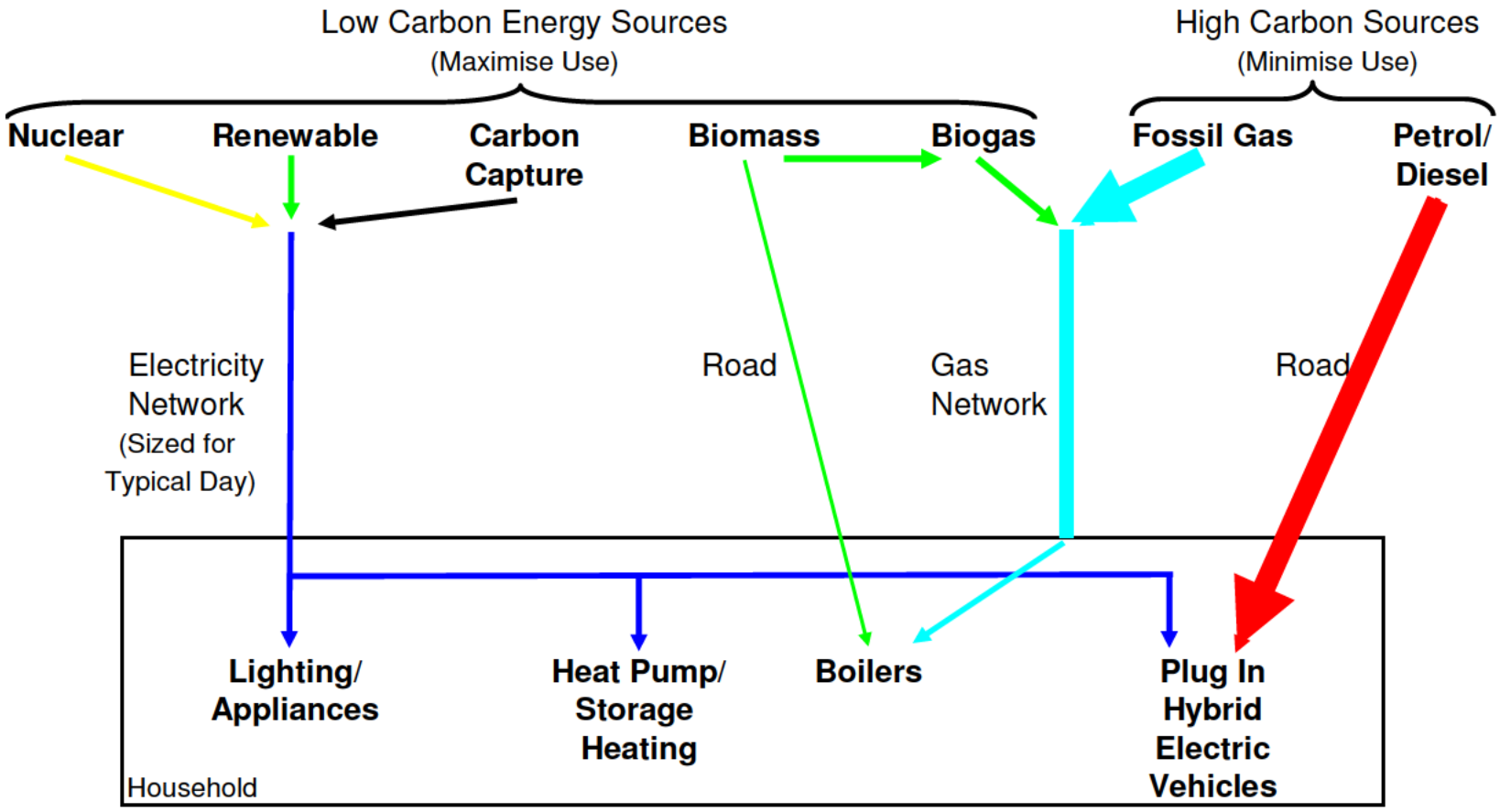
2050 – Low Wind/High Demand Day



Smart Grid manages interaction between electric and gas demand along with wind intermittency

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Matrix of sensitivities

Change (£B/annum)	>-4	-1 to -4	+-1	+1 to +6	+6 to +10	>+10
Base						
No Energy Conservation						
Cheap Wind replanting						
Heat Pumps (half price)						
Heat Pumps (CoP doubles)						
No nuclear generation						
Low nuclear						
High nuclear						
Batteries expensive						
No Gas network						
CCS unfeasable						

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Conclusions

- Key priorities from modelling
  - Energy efficiency
  - Nuclear & CCS
  - Battery technology & cost & smart technology
  - Economic wind & heat pumps
  - Use of gas/biogas for peak heating
- Other key priorities
  - Energy policy (market, SoS, communication)
  - Planning
  - Investment