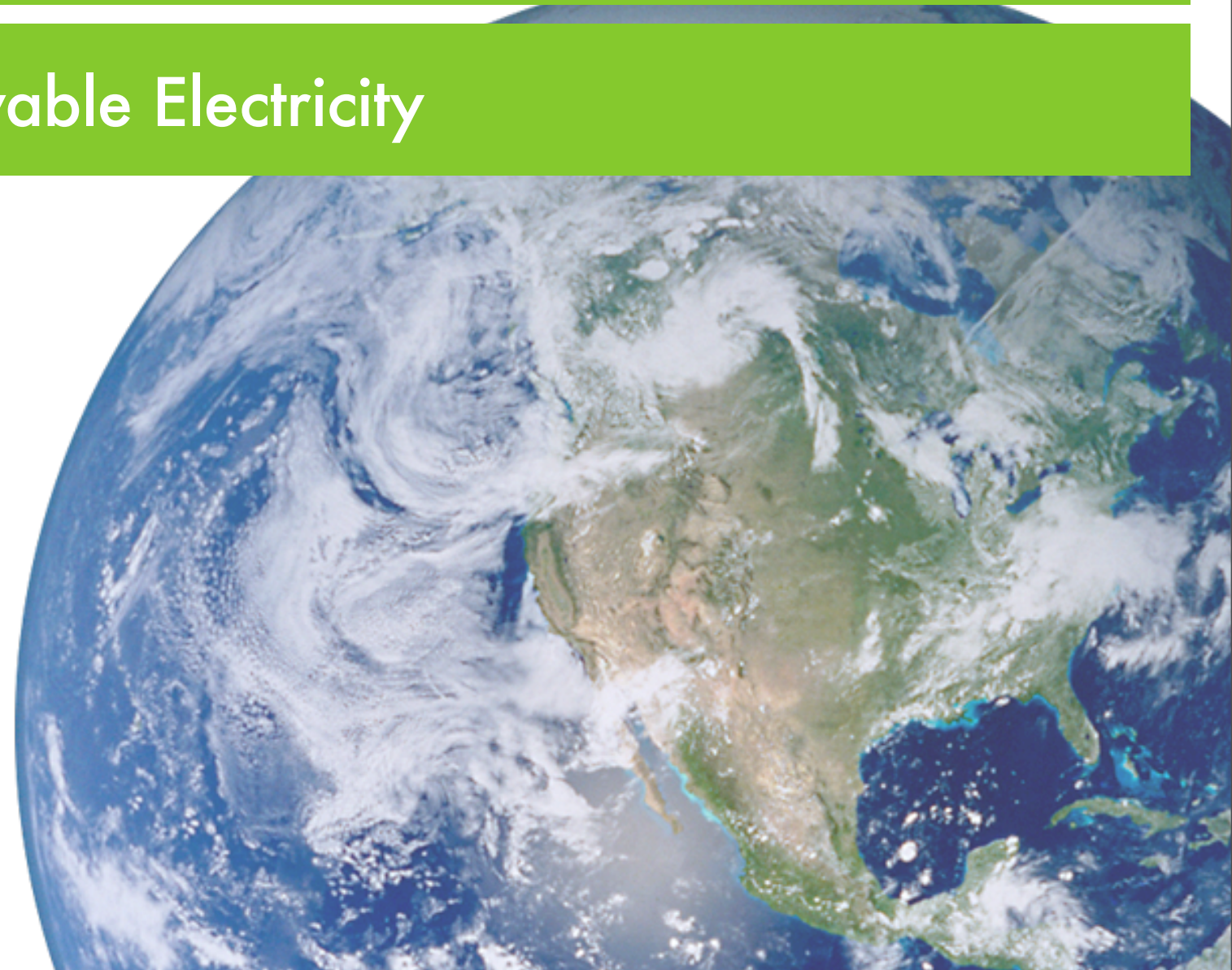


THE ImpEE PROJECT

IMPROVING
ENGINEERING
EDUCATION

Renewable Electricity



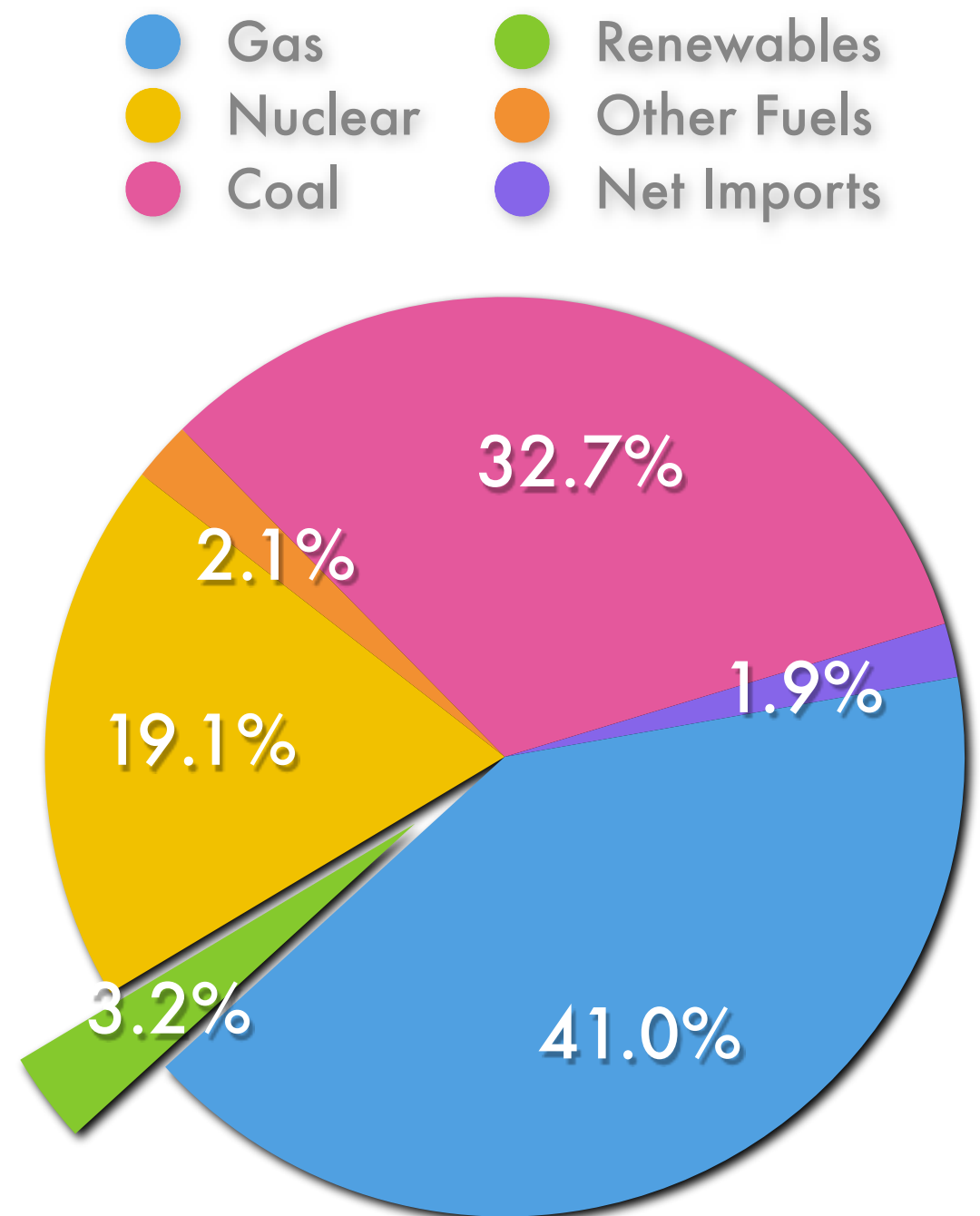
Notes

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- version 4
- June 11th, 2006

The Overall UK Electricity Market

(for 2004)

- Note that electricity represents about a quarter of the UK's consumption of primary energy. (Transport and non-electric heating are a much larger share.)
- Total UK Electricity market in 2004 was around 325 000 GWhr
- Renewable Energy currently makes up 3.2% of the mix



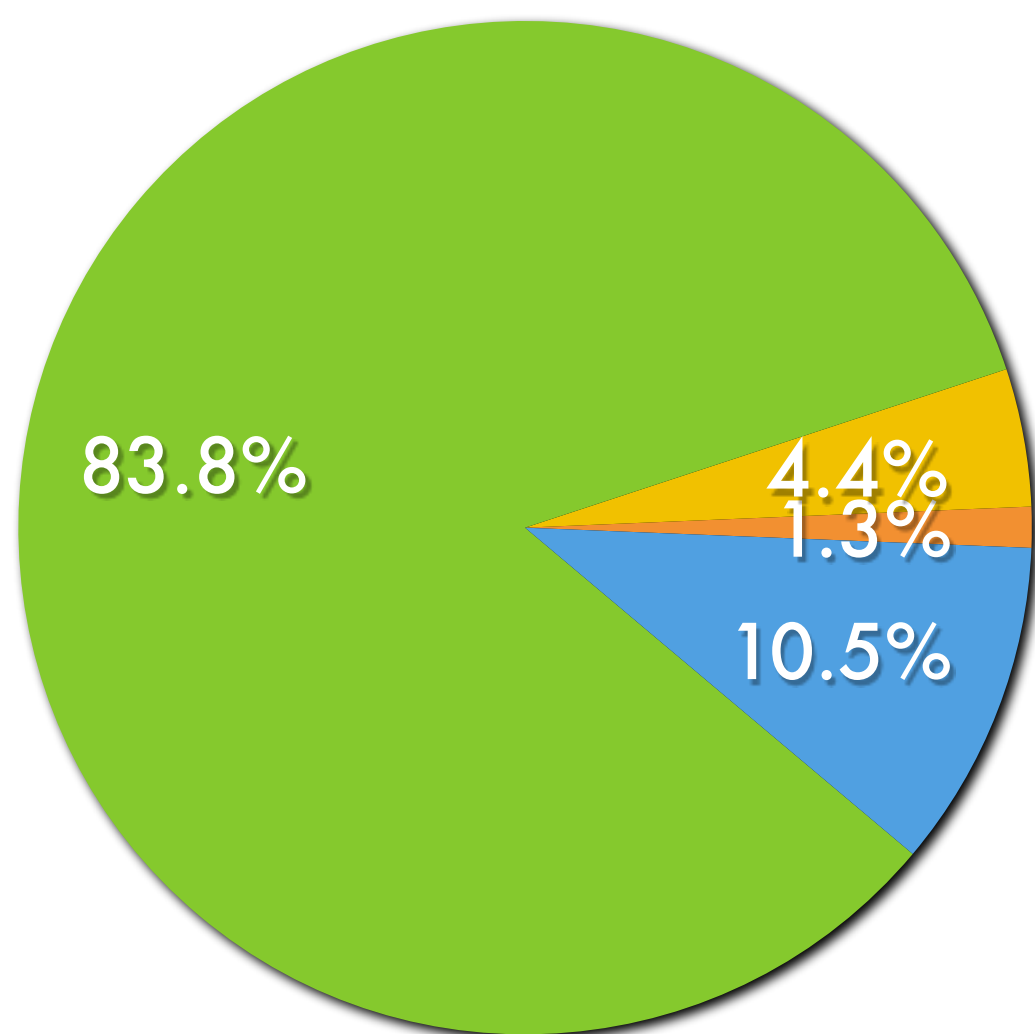
Notes

- When discussing the Electricity markets and statistics it is important to make the distinction between the overall energy consumption (which includes transport, non-electric heating and other sectors) and just the electricity sector in isolation. Electricity is around 25% of the UK's overall energy use.¹
- UK Electricity market sales was around 325 000 GWhrs; this is growing at around 0.5% per year.²
- (Not shown) Electricity demand is around 29% domestic sector, 29% industry, 18% commercial. (Transport is only 2%).²
- The data for sources of electricity in UK for 2004 used in the chart are [available for download](#). Today, natural gas is the largest contributor which has been increasing in the past decade at the expense of coal power plants. The contribution of nuclear power has been relatively constant. Renewables account for 3.2%.²

1. Sustainable Development Commission, "Wind Power in the UK".

2. DTI, "[Digest of UK Energy Statistics 2004](http://www.dti.gov.uk/energy/inform/dukes/index.shtml)", Published by The Stationary Office. (<http://www.dti.gov.uk/energy/inform/dukes/index.shtml>)

Makeup of Renewable Electricity Generation (for 2004)



- The vast majority of UK's renewable electricity currently comes from Biomass (Landfill gas, sewage gas, wood, waste combustion etc).
- Large-Scale Hydro provides 10.5% but is mature
- Despite its high profile, wind power is only 4.4% of renewables, or less than 0.15% of overall UK electricity (~ 450 GWhr)
- Solar Power is negligible

Notes

- [Download the data](#) used for graph. Statistics are from DTI.¹
 - Biomass is any fuel derived from organic matter, can be considered renewable only if harvested or grown in a managed manner. This includes everything from burning landfill gas or sewage gas, to waste combustion and wood-fired furnaces. Biomass can be "carbon neutral" even if burnt so long as the released carbon is re-trapped in the next iteration of the cycle.
 - Large-scale hydro development in the UK is complete; no further sites remain.
 - Solar Photovoltaic and Solar Thermal have great future potential but are still minor contributors.
 - Wind power is currently only at 4.4% or in other words, $3.2\% \times 4.4\% = 0.1408\%$ of overall UK electricity. Or around 450 GWhr per year.
1. DTI, "[Digest of UK Energy Statistics 2004](#)", Published by The Stationary Office. (<http://www.dti.gov.uk/energy/inform/dukes/index.shtml>)

ROCs, CCL, and Other Incentives

Pure “economic” costs are only part of the equation:

- Renewable Obligations (RO) are government policy to promote renewable generation of electricity.
- Renewable Generators are rewarded RO Certificates (ROCs) for each 1MWhr they produce.
- RO requires electricity suppliers to source an increasing percentage of their electricity from renewables (10.4% for 2010, 15.4% for 2015).
- Electricity Suppliers can meet their obligation by:
 1. Buying ROCs from renewable suppliers at a value determined by free-market economics
 2. Paying a buy-out fund contribution equivalent to £30/MWh



Notes

- The point here is that Government policy can act directly to affect the economic realities of a sector. Engineers need to be aware of this! Engineering problems don't only exist in technical quarantine!
- [Information on the Climate Change Levy](http://www.defra.gov.uk/environment/ccl/intro.htm) see <http://www.defra.gov.uk/environment/ccl/intro.htm>
- [Information on Renewable Obligations](http://www.dti.gov.uk/renewables/renew_2.2.1.htm) see http://www.dti.gov.uk/renewables/renew_2.2.1.htm

Future Trends and Directions

Motivations for the future of Renewable Energy are broad

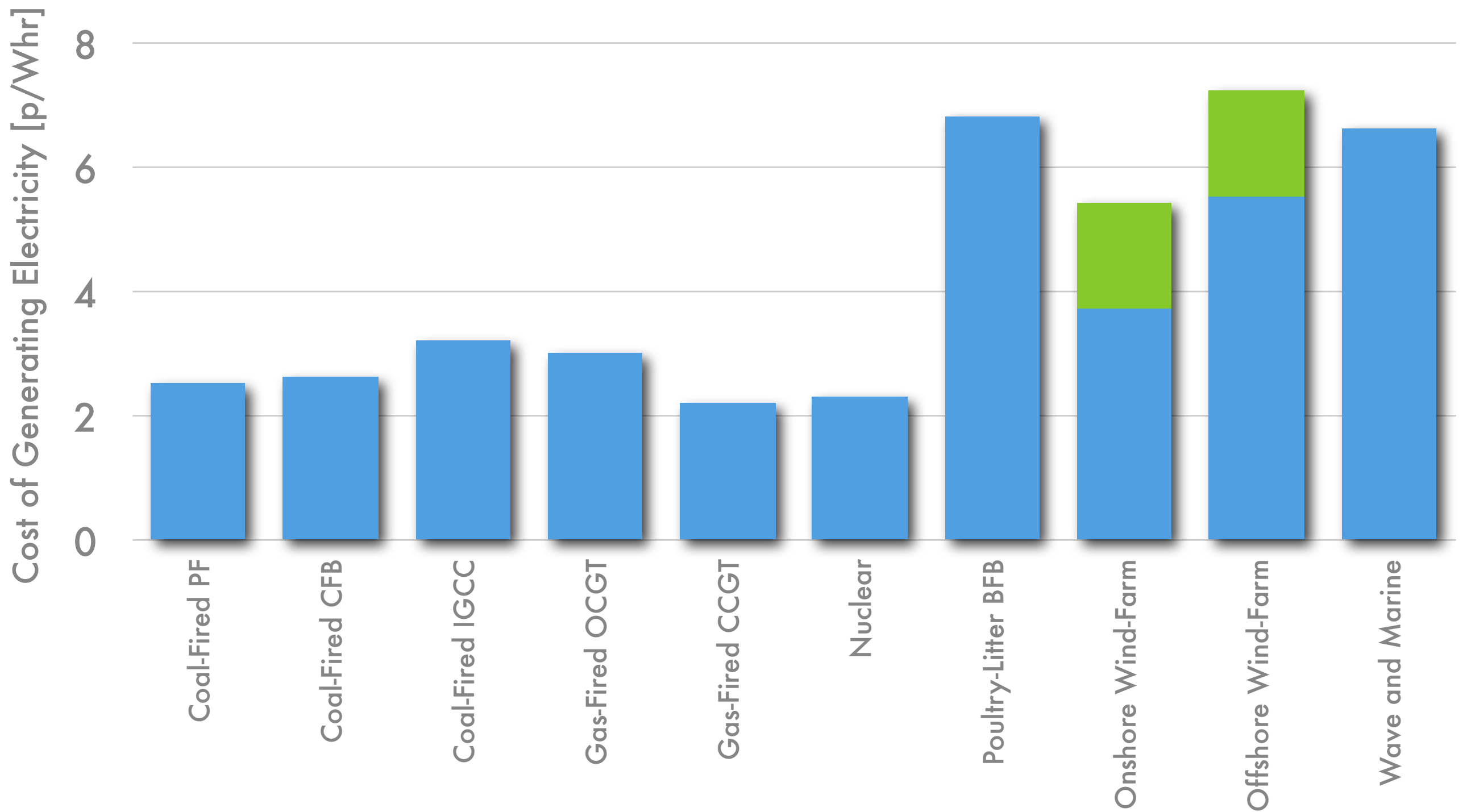
- Strategic **social** incentive for a stable energy source. See for example UK government's 10% by 2010 policy
- Reduce **environmental** impact of non-renewable energy sources. See for example CO₂ and Kyoto
- **Economic** incentive as prices of conventional sources spiral ever upwards.
- Don't forget: Better economy is the only real solution.

Notes

- The main idea of ESD: convergence of Social, Economic and Environmental Drivers
- Society's strategic need for a stable energy source. Parliamentary Office of Science and Technology Note (POST Note) No. 203 "[Security of Electricity Supplies](#)"
- The UK government has set a target of meeting 10% of its electricity demand from renewable sources: see POST Note No. 164, "[Renewable Energy](#)"
- For environmental impact of fossil-fuels and the CO₂ debate, see ImpEE Resource (link to CO₂ resource)
- Economic Incentive: give reference for trends in gas costs current and projected
- **Emphasise to students:** engineering solutions for finding new renewable and sustainable sources of energy are laudable, but the single most important thing we as a society need to do is to reduce our electricity consumption! Link to ImpEE Resource on consumption.

Costs

■ Cost of Generating Electricity
 ■ Standby Generation Cost



Notes

- Source: 'The costs of generating electricity', PB Power, Royal Academy of Engineering, March 2004
- A report generated for the Royal Academy of Engineering in 2004 provides these costs. Note that calculating true costs for energy generation is difficult and likely to always have criticisms. These figures should be used to provide an idea of the relative costs rather than an absolute reference.
- These figures represent just the cost to generate electricity (in pence per kWh) delivered at the boundary of the power station site. This cost value includes the capital cost of the generating plant and equipment; the cost of fuel burned (if applicable); and the cost of operating and maintaining the plant in keeping with UK best practices. With the exception of nuclear, the analysis assumes that decommissioning is cost neutral. The capital cost estimate for nuclear plant includes an allowance for the decommissioning. The cost values do not account for added cost of carbon emissions.
- Some renewables, such as wind, have inherent fluctuations in the energy source itself requiring additional, fast response, standby generating plant to maintain system security as the energy source fluctuates.

List of Abbreviations:

PF = pulverised fuel
 CFB = circulating fluidized-bed
 IGCC = integrated gasification combined cycle
 OCGT = open-cycle gas turbine
 BFB = bubbling fluidized bed. Poultry litter BFB steam bed

How much CO₂ do renewables displace?

Fuel Type	kg CO ₂ per kWhr	kg CO ₂ per tonne	kg CO ₂ per litre
Grid Electricity ¹	0.43	-	-
Natural Gas	0.19	-	-
Fuel Oil	0.27	3223	-
Diesel	0.25	3164	2.63
Petrol	0.24	3135	2.30
Other Coal ²	0.32	2548	-
Aviation Fuel	0.25	3150	2.52

^{1,2} See Notes

July 2005

Notes

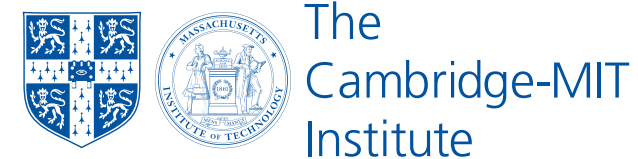
- Source: Based on the National Atmospheric Emissions Inventory for 2003 and the UK Greenhouse Gas Inventory for 2003 developed by Netcen (2005), Digest of UK Energy Statistics DTI 2004
- The amount of CO₂ emissions saved by using zero-emissions renewable electricity options varies depending on the non-renewable fossil fuel it displaces. These figures can act as a guideline for making those calculations. The data is from the UK Department for Environment Food and Rural Affairs (DEFRA) July 1995 guide for calculating Company Reporting on Greenhouse Gas Emission. The report can be [downloaded](http://www.defra.gov.uk/environment/business/envrp/gas/envrpgas-annexes.pdf) as a PDF. <http://www.defra.gov.uk/environment/business/envrp/gas/envrpgas-annexes.pdf>

1. The factor for grid electricity was calculated on the projected fuel mix for the grid 1998–2000. Actual figures may differ from the projections.
2. This is the average emission factor for coal used in sources **other** than power stations and domestic, i.e. industry sources including collieries, Iron & Steel, Autogeneration, Cement production, Lime production, Other industry, Miscellaneous, Public Sector, Stationary combustion – railways and Agriculture.



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