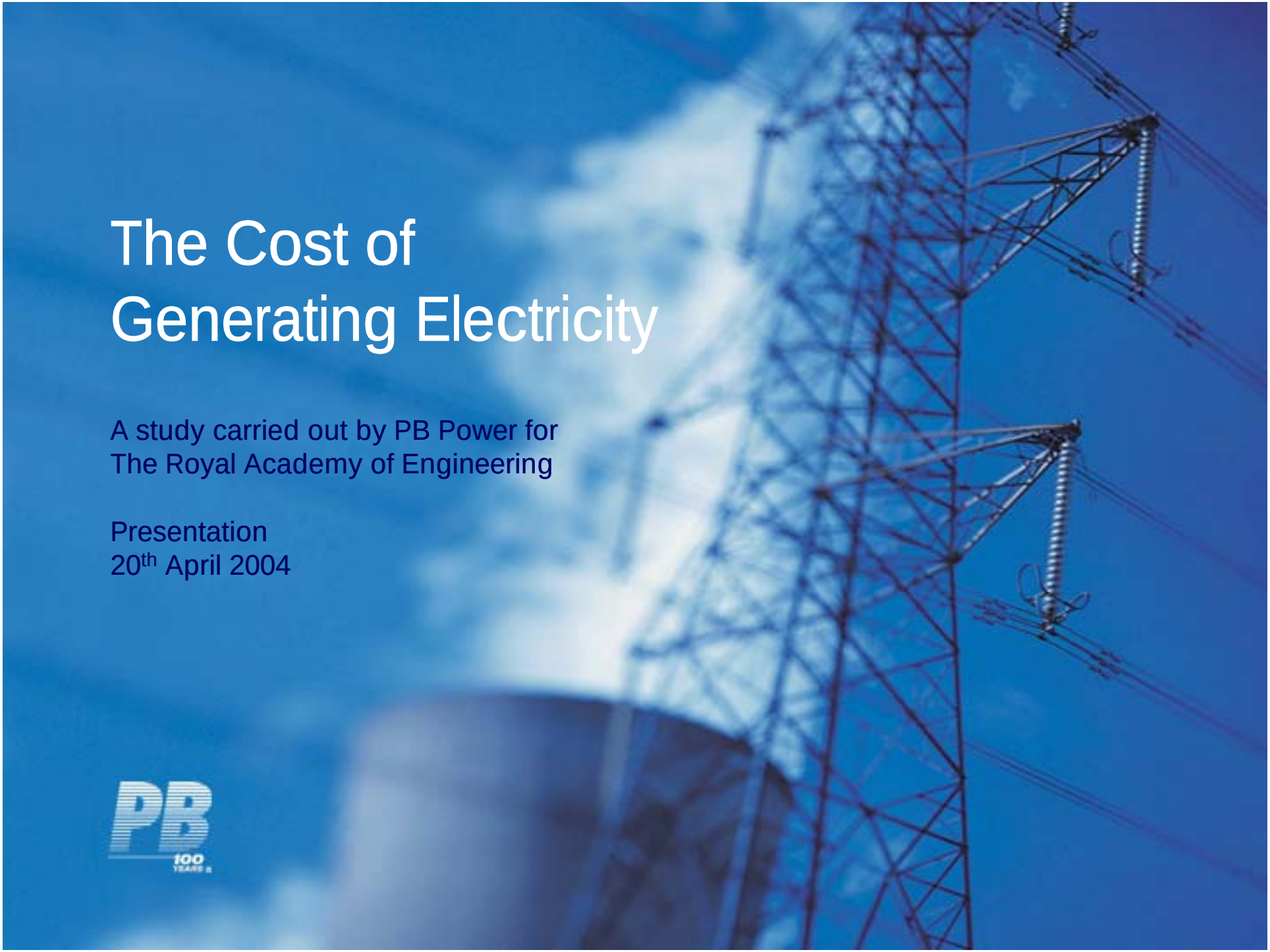


The Cost of Generating Electricity

A study carried out by PB Power for
The Royal Academy of Engineering

Presentation
20th April 2004

Overview of presentation

- Terms of reference
- Principal assumptions
- Intermittency
- Results
- The cost of generating electricity
- PB Power

Terms of reference

- Simple, soundly based, indicators of cost performance for a range of different technologies and fuels
- Focus on ‘bankable’ projects over next 15 to 20-years
- Compliant with existing and future environmental legislation
- Taking account of the costs of intermittency and carbon dioxide emissions.
- Cost of the plant itself (EPC cost) net of soft-costs, e.g. developer costs, financing charges etc.

Principal assumptions

- Generation costs not electricity prices
- Cost as delivered to the boundary of the power station site
- Included cost of fuel and O&M: with allowances for labour, business rates and insurance
- Excluded costs associated with transmission /distribution and other system costs
- Real discount rate = 7.5% p.a.
- Levellised cost calculated over economic life of asset

…capital costs

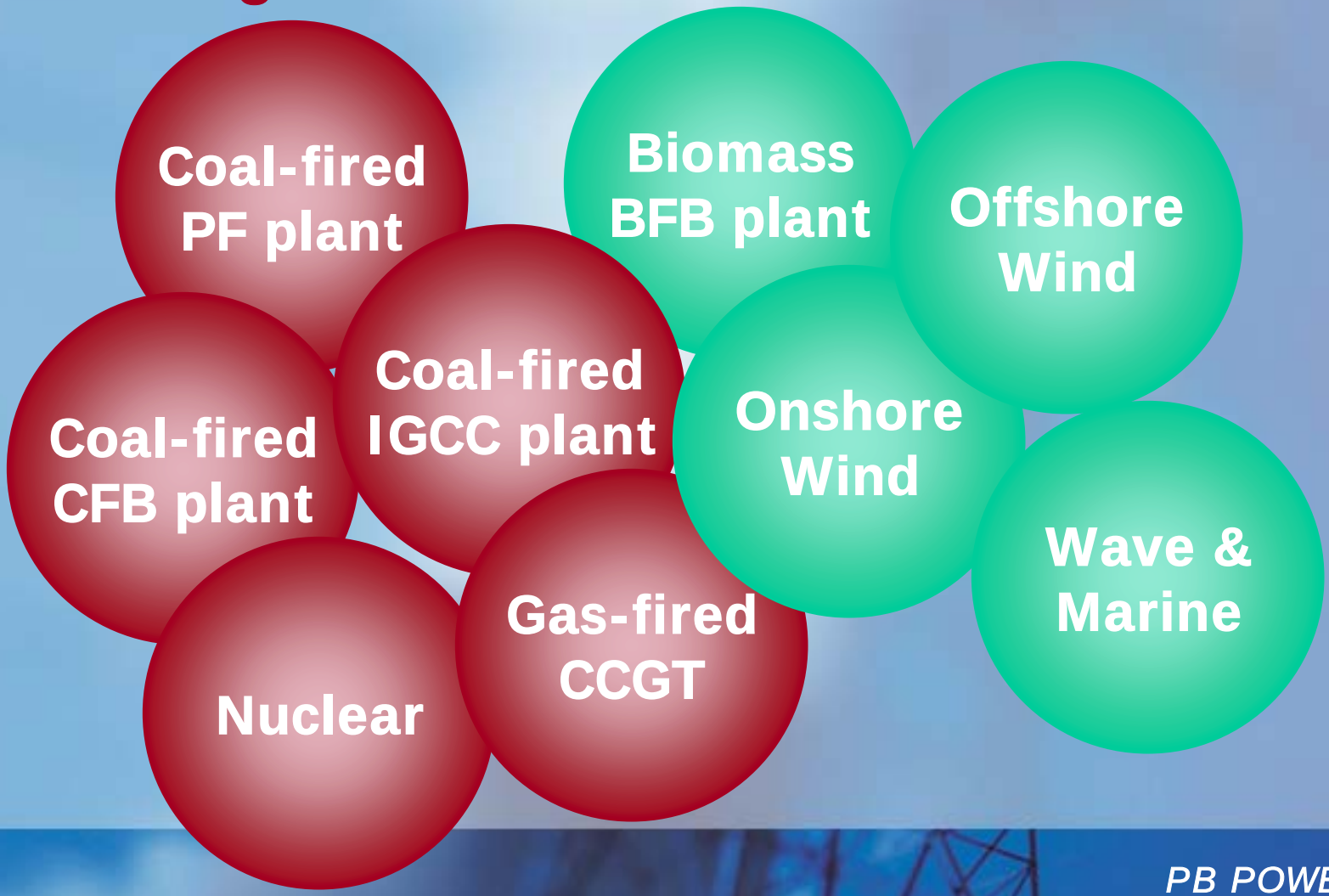
- Capital cost of the generating plant itself (EPC cost) net of soft-costs, e.g. developer costs, financing charges etc. (soft-costs can account for an additional 15 to 25% on top of the EPC cost)
- Costs mostly taken from recent contracts
- Allowances made for envisaged cost reductions in wind turbine technology (15%)
- Wave/marine highly speculative costs owing to immaturity of technology
- Nuclear based on reported TVO contract price

…fuel prices

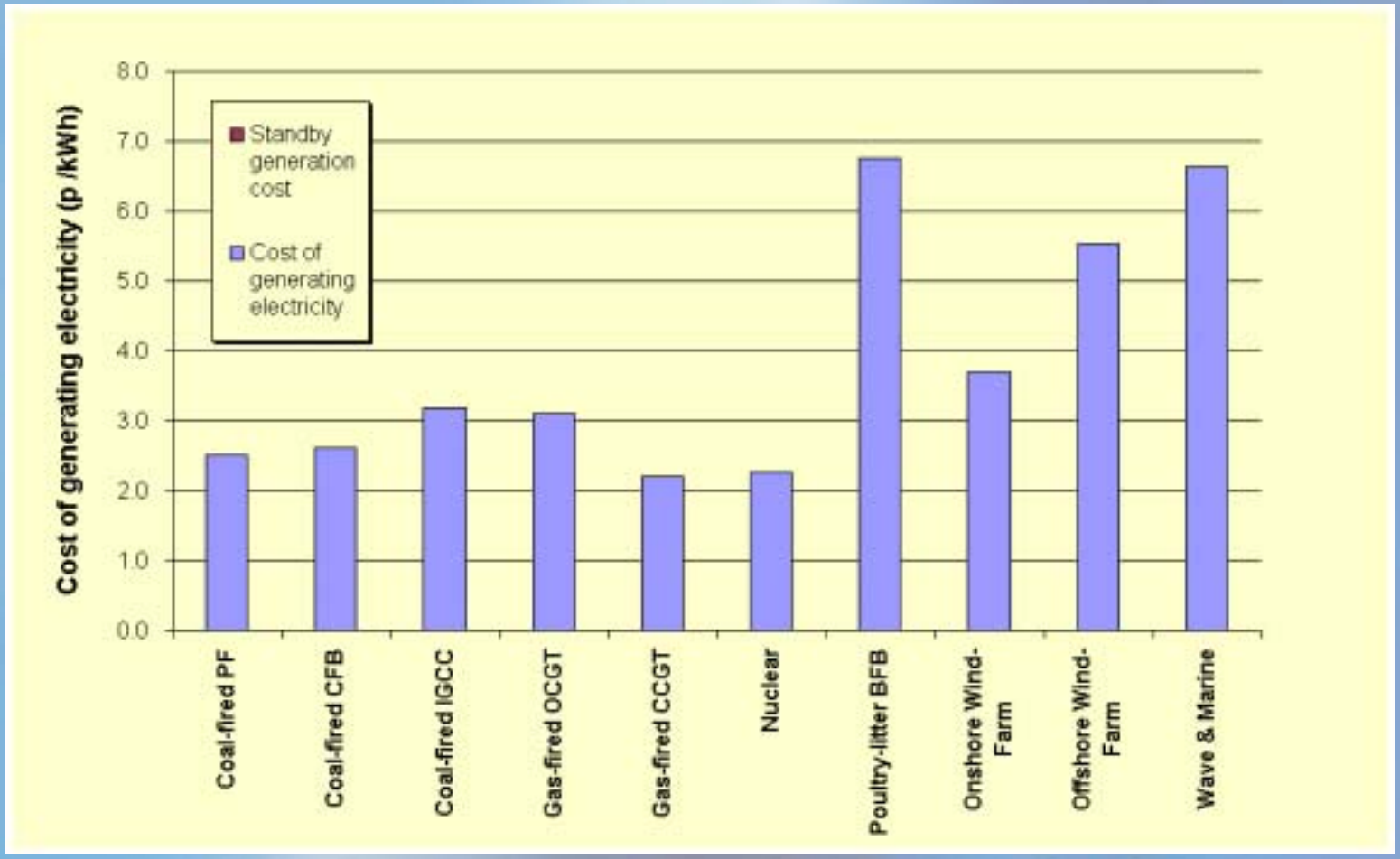
- Long-term view of coal and natural gas prices
- Heavy fuel-oil excluded because of high excise duty

			(£ per GJ)
Natural gas	(p /therm)	23.0	2.18
Coal	(£ /tonne)	30.3	1.16

…technologies considered



Results (excluding standby costs)



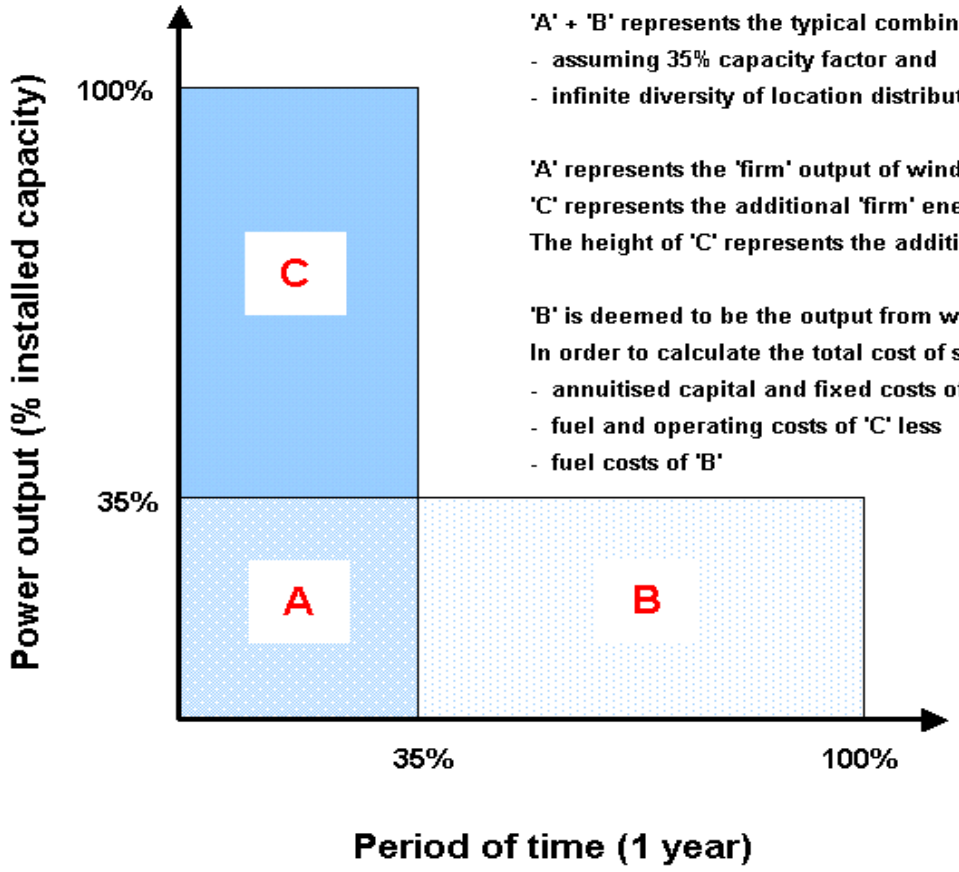
Cost of intermittency

- All generation technologies exhibit some degree of ‘intermittency’ or ‘unpredictability’
- Fluctuations in the supply of primary energy to wind turbines means that they require special treatment
- Lack of long-term historical generation data makes it difficult to quantify the affect of wind intermittency
- Assumed ‘firm capacity’ equal to 35% of installed capacity (Milborrow) – upper limit
- Planned and forced outage rates not available for immature technology, offshore wind in particular

…approach

- Use of a proxy for standby capacity to make the output from wind turbines ‘firm’ (or dependable)
- OCGT (aero-derivative) provides cheapest, quick response, standby capacity – assumed to be unmanned installation
- Assume infinite diversity of output from individual wind turbines. Therefore, generation contribution is assumed to be equivalent to a CCGT plant with 35% capacity of installed wind turbine capacity

…principle



'A' + 'B' represents the typical combined output from wind farms:
- assuming 35% capacity factor and
- infinite diversity of location distributed through the UK

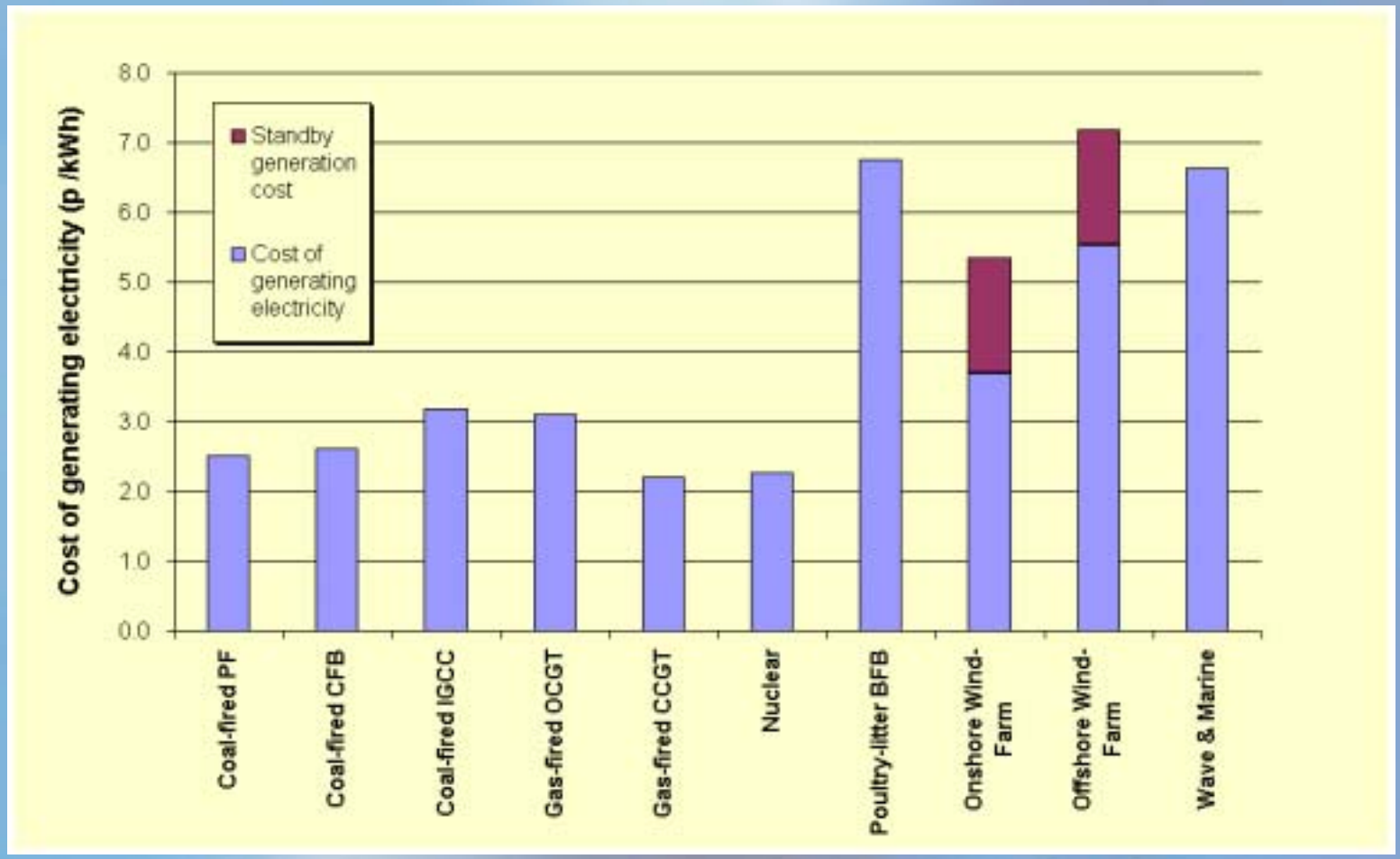
'A' represents the 'firm' output of wind turbines
'C' represents the additional 'firm' enegy provided by standby generation
The height of 'C' represents the additional 'firm' capacity provided by standby generation

'B' is deemed to be the output from wind turbines which displaces CCGT generation
In order to calculate the total cost of standby generation:
- annuitised capital and fixed costs of 'C' plus
- fuel and operating costs of 'C' less
- fuel costs of 'B'

…discussion

- Assume that costs of standby capacity due to fuel intermittency are 100% attributed to the wind turbines themselves
- Indicate principle of costs which might exist if the installed capacity of a wind farm were sized with a discrete load of similar magnitude
- Results do not attempt to emulate the actual costs of increasing levels of wind turbine penetration in the UK

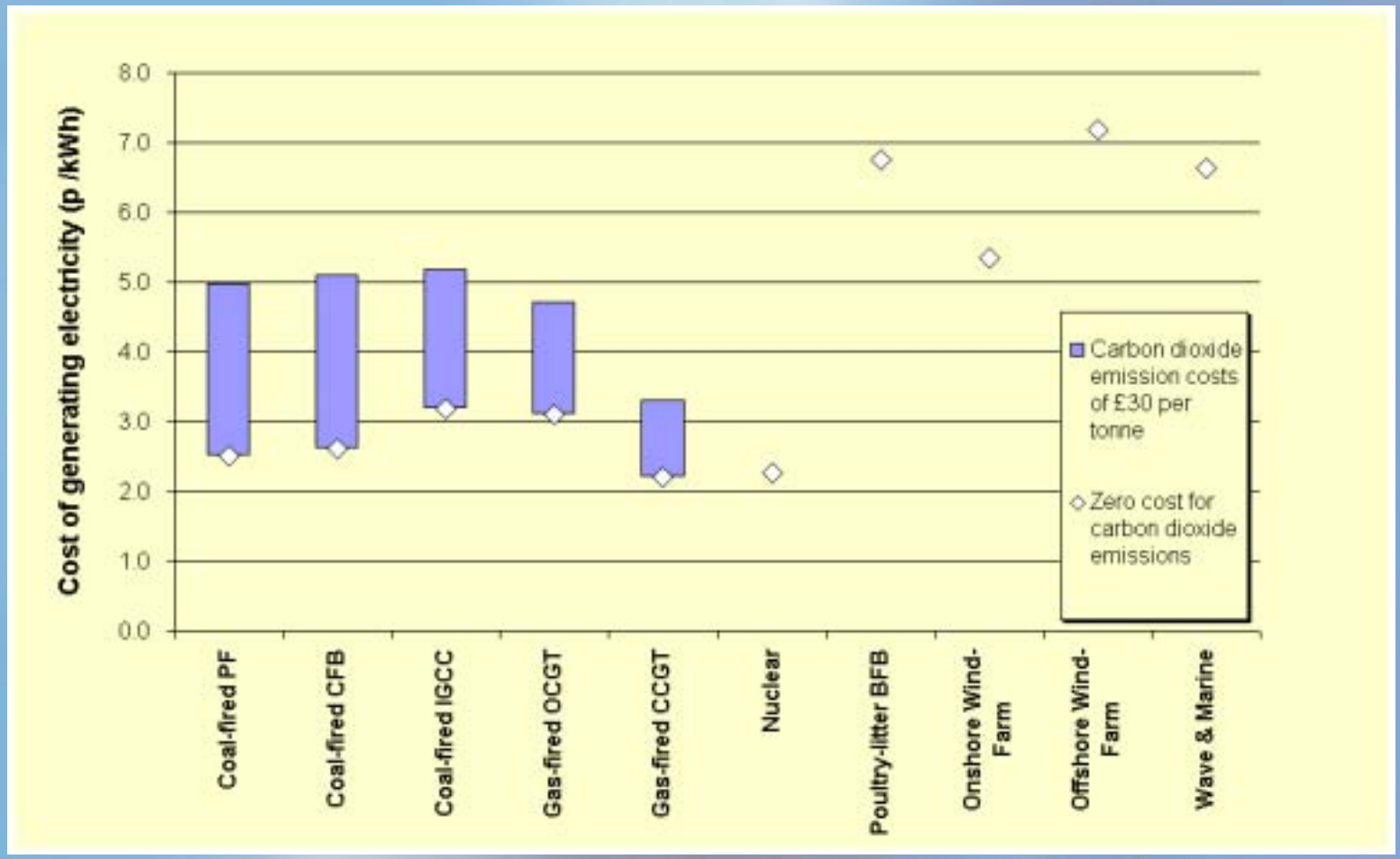
Results (including standby costs)

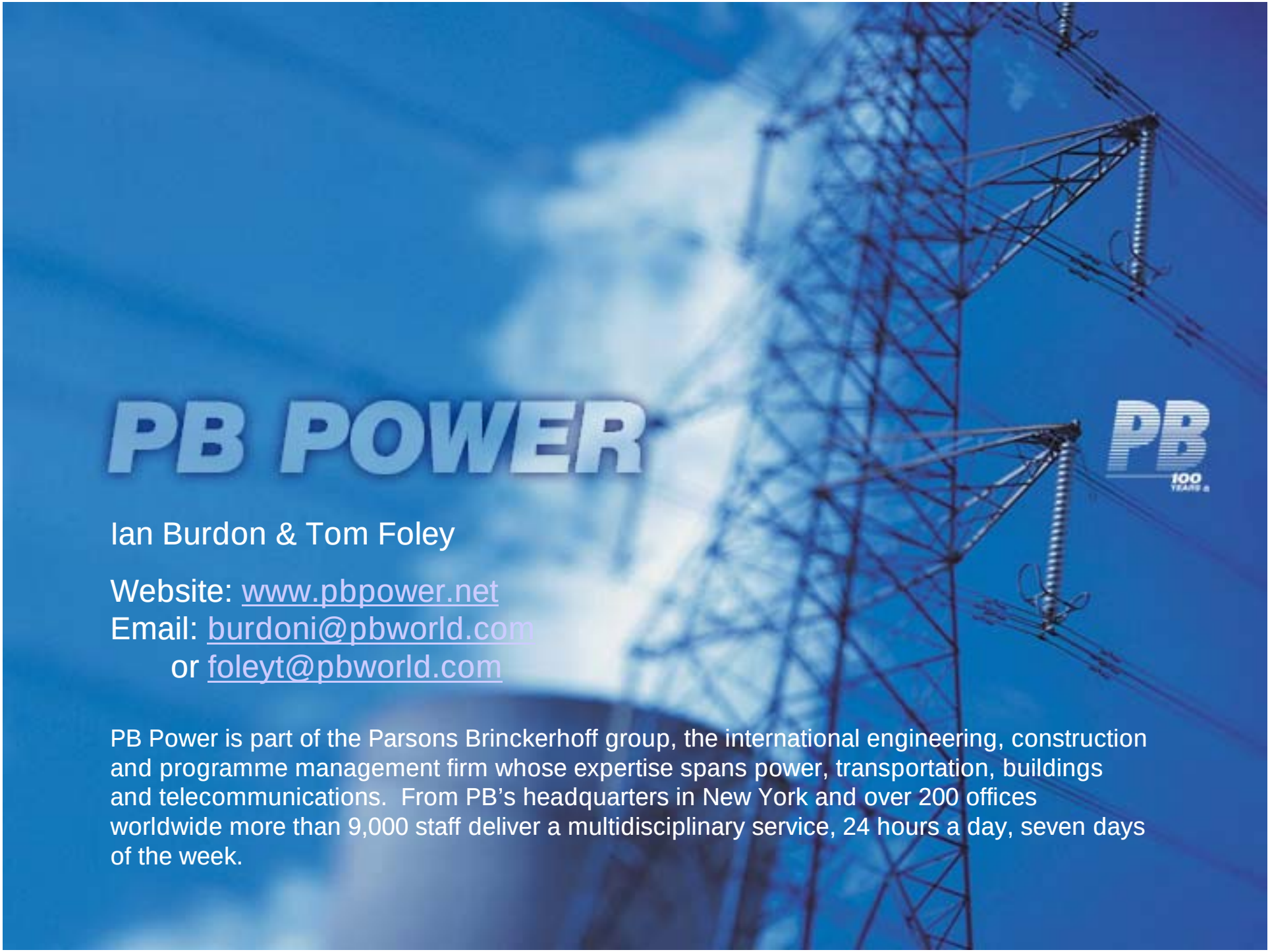


Cost of CO_2

- Conservative view of free allocation of carbon credits to new entrant plant – cost applied to 100% of output
- Market price assumed to range from zero to £30 per tonne
- Increasing cost of CO_2 will penalise hydrocarbon fuel based generation – coal more so than natural gas

The Cost of Generating Electricity





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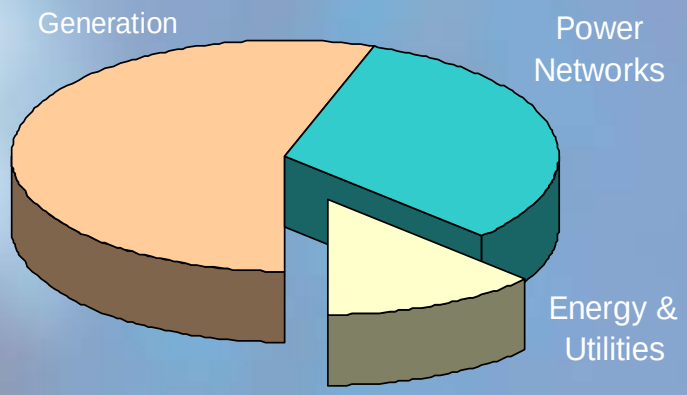

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