ROYAL ACADEMY of ENGINEERING

The Cost of Generating Electricity

A COMMENTARY

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

Costs of Generating Electricity

Commentary by the Royal Academy of Engineering

The Royal Academy of Engineering commissioned PB Power to conduct a study of the comparative costs of generating electricity from a number of available technologies. The full results of that study are contained in the Academy's report "Costs of Generating Electricity" and this document serves as both an Executive Summary and as a Commentary on the work performed by PB Power.

Introduction

In order to make sensible decisions about energy policy for the UK, policy makers need to be able to compare the costs and benefits of different types of electricity generating technologies on a like for like basis. Unfortunately, the UK electricity market is complex. The relationship between the cost of generating electrical power from various sources and the price that consumers pay is blurred by direct and indirect subsidies, market mechanisms, transmission and distribution costs. The true costs of generating electrical power are often obscured by commercial sensitivities and competing claims that make the determination of sensible energy policy difficult and often imprecise.

The Royal Academy of Engineering has taken a keen interest in energy policy and has often been concerned about the lack of clarity between competing claims over what is the best mix of generation and how the electricity market should be manipulated to achieve the aims of the Government's current energy policy. To help improve understanding, the Academy has attempted to compare the costs of generating electricity from a number of different technologies in an even-handed and dispassionate manner and commissioned PB Power to carry out a study. The results of the study are contained in the Academy's report, *The Costs of Generating Electricity.*

The complex financial structures of commercial projects mean that it is often impossible to compare the capital costs of generating plant in a meaningful manner. This study has taken what we know to be the actual costs of building, maintaining and running various types of power station in the UK and derived costs of producing electricity by using a common financing model with a nominal discount rate of 7.5%. It compares new build power stations on a level playing field and examines their sensitivities to emissions costs and fuel prices. The figures presented here are therefore indicative rather than predictive. However, unlike many other compilations of costs, they compare like with like and therefore will be of immense use to policy makers.

Scope

The objective of this study is to provide decision makers with simple, soundly based indicators of the cost performance for alternative electricity generation technologies. The scope required a certain amount of simplification and approximation of issues that would be of utmost importance to a commercial organisation making an investment decision in the electricity generation market. These include treatment of risk and uncertainty, security of supply of fuel and project financial structures as well as market and regulation issues. The Academy believes that a more comprehensive treatment would be of value to policy makers.

The complexities of the UK electricity market also mean that there are a large number of non-trivial, variable costs that are not specific to the technologies used to generate electricity. These all have a bearing on the price that the consumer eventually pays, but as these costs are often spread across the whole market as system operating costs, they were therefore excluded from this study. Further examination of these system costs, especially the impact of transmission costs, could also prove valuable.

Results

The study examined a number of different technologies listed below.

- Coal plant
  - Pulverised fuel (PF) steam plant;
  - Circulating fluidized-bed combustion (CFBC) plant;
  - Integrated gasification combined-cycle (IGCC) plant;
- Gas plant
  - Open-cycle gas turbine (OCGT) plant;
  - Combined-cycle gas turbine (CCGT) plant;
- Nuclear fission plant.
- Biomass (poultry litter)
  - Bubbling fluidized-bed combustion (BFBC) plant;
- Wind turbines
  - Onshore
  - Offshore
- Wave and Marine

The PB Power report arrived at the following results:-

The cost of generating electricity, as defined within the scope of this study, is expressed in terms of a unit cost (pence per kWh) delivered at the boundary of the power station site. This cost value, therefore, includes the capital cost[1] 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. Within the study, however, the 'cost of generating electricity' is deemed to refer to that of providing a dependable (or 'firm') supply. For intermittent[2] sources of generation, such as wind, an additional amount has been included for the provision of adequate standby generation. The findings of this study are summarised in Figure 1, which illustrates the present-day costs of generating electricity from different types of technology appropriate to the UK:

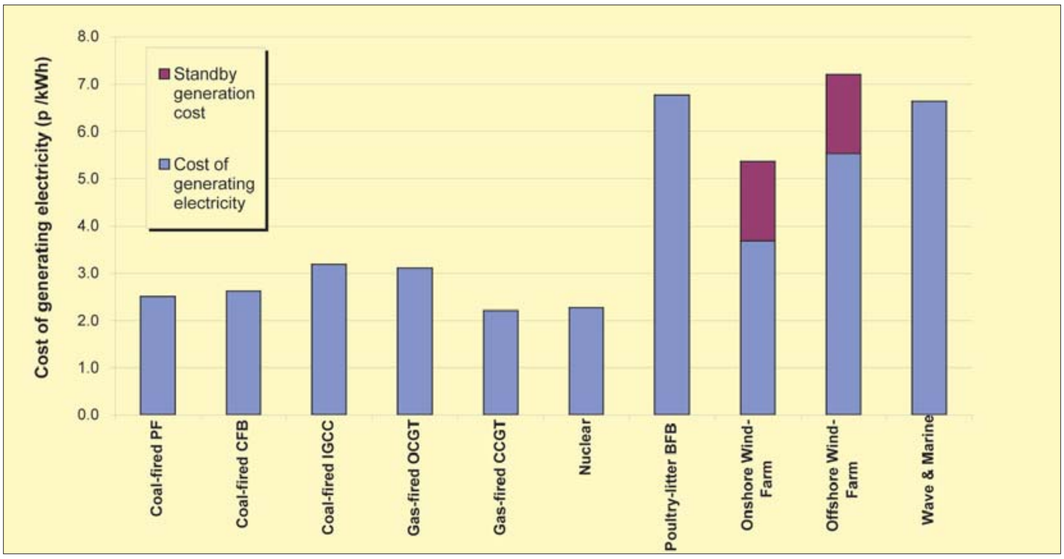

Figure 1 *Cost of generating electricity (pence per kWh) with no cost of CO2 emissions included.*

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[1] *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 costs of decommissioning.*

[2] *For the purpose of this study, wave and marine technologies are deemed to be predictable and therefore have not been burdened with the additional cost of standby generation.*

For base-load operation, i.e. those plants which are operated continuously, the cheapest way to generate electricity in the future from new plant, i.e. ignoring rehabilitation of existing plant, is by constructing combined-cycle gas turbine (CCGT) plant designed to burn natural gas.

Table 1 summarises the cost of generating electricity for the different 'base-load' plants considered by this study.

Gas-fired CCGT	2.2
Nuclear fission plant	2.3
Coal-fired pulverised-fuel (PF) steam plant	2.5
Coal-fired circulating fluidized bed (CFB) steam plant	2.6
Coal-fired integrated gasification combined cycle (IGCC)	3.2

Table 1 *Cost of generating electricity for base-load plant (pence per kWh)*

For peaking operation, i.e. generating for limited periods of high demand and providing standby capacity, open-cycle gas turbines (OCGT) fired on natural gas are the most appropriate new plant candidates. OCGT is ideally suited for the role of peaking duty, which requires flexibility, reliability and can be started quickly should the need arise. We estimate that the cost of a gas-fired OCGT generation will be about 3.1 pence per kWh if operated continuously. However, the average cost will rise to about 6.2 pence per kWh if only operated for limited periods of time consistent with peaking duty, i.e. for only 15 per cent of the time, say.

Renewables are generally more expensive than conventional generation technologies. This is due in part to the immaturity of the technology and the more limited opportunity to take advantage of cost savings brought about by economies of scale usually associated with more traditional fossil-fuel types of generation. In addition, fluctuations in the energy source itself may limit the output of generation available from these technologies and, thus, raise the unit costs of the generator on two counts:

- as capacity factor[3] falls, unit costs of generation rise;
- additional, fast response, standby generating plant may have to be provided to maintain system security as the energy source fluctuates.

[3] *'capacity factor' is an operational term to represent the extent to which the generator is producing electricity over a period, e.g. a year. Wind turbines have typical capacity factors of 25-45 per cent whilst large coal or nuclear plants may have capacity factors in excess of 90 per cent when operating on base-load.*

Table 2 summarises the cost of generating electricity, with and without the additional cost of standby generation, from the selection of renewable technologies considered by this study.

	Without standby generation	With standby generation
Poultry litter-fired bubbling fluidized bed (BFB) steam plant	6.8	6.8
Onshore wind farm	3.7	5.4
Offshore wind farm	5.5	7.2
Wave and marine technologies[4]	6.6	6.6

Table 2 *Cost of generating electricity for selected renewables (pence per kWh)*

Although the fuel component of electricity may represent as much as 70 per cent of the total cost of production, deriving a detailed forecast of future fuel prices was outwith the scope of this study. In order to compare the costs of different fuels used in electricity generation, we have taken a pragmatic view of historical prices and the key drivers affecting fuel prices moving forward to derive reasonable benchmarks from which to perform sensitivity analyses.

Figure 2 illustrates the effect on the cost of generating electricity given a change of ±20 per cent in fuel price, where the base cost of coal is £30 per tonne and natural gas is 23 pence per therm.

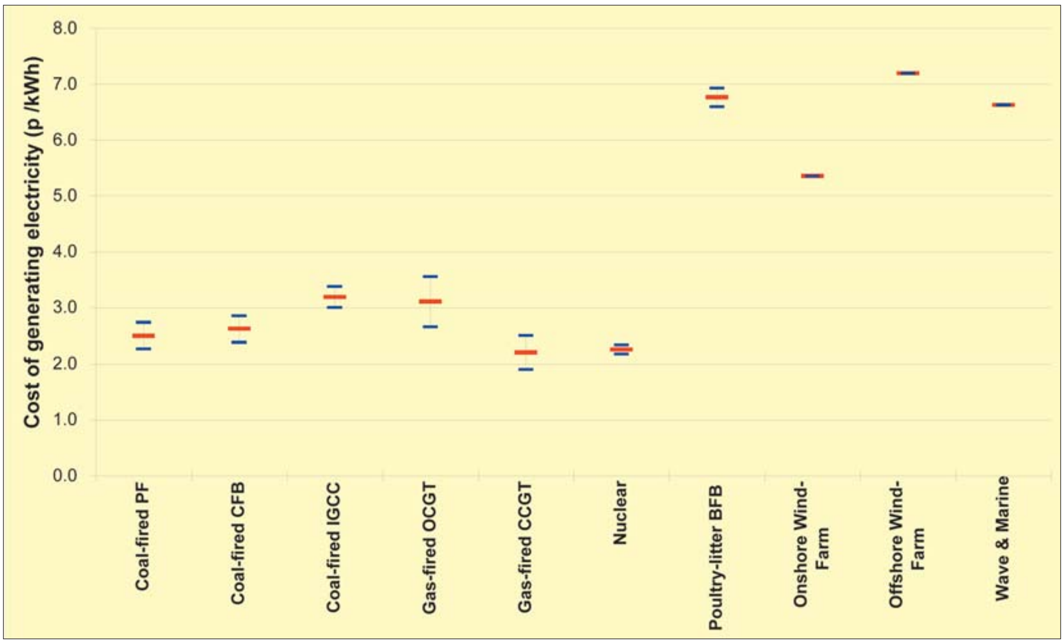

Figure 2 *Effect of ± 20% change in fuel price on the cost of generating electricity*

[4] *The additional cost of standby generation for wave and marine technologies has not been included because only low levels of penetration are expected within the study horizon.*

At the time of writing this report, no firm commitment has been given by the Government on how carbon dioxide (CO_2) emission allowances will be allocated to new entrant generation plant for the period 2005 to 2007. In view of this uncertainty, a conservative approach has been adopted by the study to burden 100 per cent of the output from fossil fuelled generation with a notional cost, calculated in terms of £ per tonne of CO_2 released. For the purposes of this study, a range of values between zero and £30 per tonne was used, where the upper limit reflects the reported cost of CO_2 sequestration.

Figure 3 illustrates the potential increase in generating costs brought about by the introduction of carbon emission allowances.

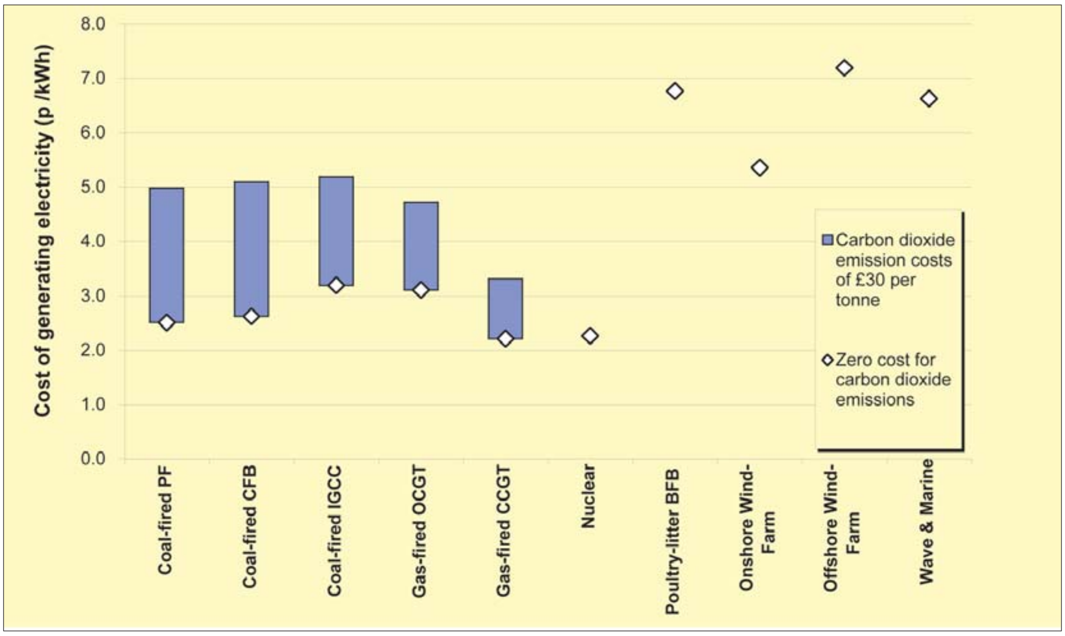

Figure 3 *Cost of generating electricity with respect to carbon dioxide emission costs. (Zero to £30 per tonne)*

It is clear that CO_2 costs will only affect those technologies burning fossil-fuels. The lower efficiency of steam plant, combined with the greater level of carbon found in coal compared with natural gas, means that the gap between CCGT plant and other coal-fired technologies will widen as the cost of CO_2 increase. The cost of nuclear and other renewables (deemed to be carbon neutral) remain unchanged and, therefore, become more competitive as the specific cost of CO_2 emissions increases.

Conclusions

The issues to be addressed when considering an energy policy include: security of supply, environmental impact, national competitiveness and social concerns. Each technology examined in this study has its own set of characteristics that are valued to more or lesser extents depending on the context and which have a bearing on four issues above. Hence, the mix of generation cannot and should not be determined solely by cost, but a rigorous understanding of those costs will enable policy makers to understand the levels of subsidy or market manipulation that is required to give a desired outcome. Furthermore, those market mechanisms and subsidies should relate directly to the particular form of generation and the perceived benefit rather than being smoothed across the system, giving rise to cross subsidies.

The renewables sector already benefits from subsidies worth in the region of £485 million a year through the Renewables Obligation and concern has been expressed[5] that Government plans to offer further subsidies (e.g. reductions in transmission charges), through amendments to the Electricity Bill, will not lead to extra investment. This may also run counter to the spirit of the new European Electricity Directive aimed at promoting competitive energy markets and could be regarded as further distortions to the market.

This examination of the costs of generating electricity is a foundation upon which discussion about future energy policy including subsidies and market mechanisms can be based.

Critical Issues

This study has highlighted some areas where better understanding of comparative costs would be useful in the formation of energy policy:

1. While this study provides a set of comparative figures for the costs of generating electricity, a number of factors have been simplified and certain assumptions made. This study should be built upon and the methodology refined to include other issues that influence the decisions of commercial operators in the electricity generation market.

2. A number of elements of the cost of electricity are hidden or shared throughout the system rather than allocated to specific generators. These are balancing costs and transmission costs which also deserve further examination

3. Further scrutiny of the commercial claims for nuclear power would be useful because of the lack of data from existing new-build projects

4. The variability of prices for emissions and Renewable Obligation Certificates introduces a level of risk into financing both renewable and conventional plant.

5. Security of supply of electrical power has recently been raised as significant issue by some commentators. Further study of the risks to secure fuel supplies (particularly natural gas) and transmission system stability would usefully add to the debate at a policy level.

6. Policy makers could derive significant value from regular updates of this study and further work into the costs of electricity transmission and distribution, in particular the costs of reinforcement and re-engineering that the grid and distribution systems will require to support the Government's targets for renewable generation.

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[5] *Ofgem press release, 13 February 2004, http://www.ofgem.gov.uk/temp/ofgem/cache/cmsattach/5915_r1404_13feb.pdf*

The Royal Academy of Engineering

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