CHAPTER 12
FUEL CELL ECONOMICS

If we are to understand why fuel cells have been used only very little so far and to predict what will be their most favourable application in the future, then we must know something about the economics of their operation and compare this with the economics of other forms of energy conversion. In this chapter we shall try to evaluate the economic factors of fuel cell operation and make some attempt at comparison with its competitors, although this will not be very satisfactory since any costs chosen at the time of writing may be quite wrong by the time this book is read. In fact, of course, the whole field of economics is subject to this uncertainty and this must be borne in mind throughout the chapter.

After an initial consideration of the general economics of fuel cell operation, it will be most convenient to divide our examination into three parts concerned with low, medium, and high power batteries, and these will correspond more or less with the different kinds of application described in the last chapter.

The basic division of economic factors
There are three elements concerned in the economic analysis of fuel cell operation.
(1) Fixed capital expenses.
(2) Fixed working expenses.
(3) Proportional working expenses.

They may be explained further as follows.
The fixed capital expenses include:
(1) The interest on the capital expended on the equipment and building.
(2) The amortisation (or writing off) of this equipment.
(3) The amortisation of any setting up expenses, and possibly of design and research costs attributed to the project.
(4) Insurance.
(5) Rates and taxes on equipment, buildings and site.
(6) Some allowance for inflation and possible devaluation.

All of these charges are constant and do not normally vary from year to year. Moreover they are not obviously related to the power output of the installation.
The fixed working expenses include:
(1) Wages and salaries of maintenance and operating staff.
(2) Supplies for maintenance (not for operation).
(3) Fuel for maintenance (not for operation).
These costs cover the maintenance of the power plant, whether it is used or not.

The proportional working expenses are essentially only the cost of fuel and oxidant, if used, although they may also include any additional costs required to produce maximum power.

The cost of electrochemical energy conversion in a fuel cell
For a fuel cell working at maximum power, $P_{\text{max}}$, the values of the three elements described in the previous section can be fairly readily obtained. The fixed capital expenses element, $R$, is given by

$$R = \frac{C_{\text{max}}(x + 1/L)}{W}$$

where $C_{\text{max}}$ is the investment cost per unit power of $P_{\text{max}}$, $L$ is the lifetime of the installation, $x$ is the rate of interest payable on the invested capital, and $W$ is the fraction of the year when the cell is in operation.

The fixed working expenses element, $F$, is given by the cost of operation of the whole installation in unit time divided by the maximum power produced, $P_{\text{max}}$.

The proportional working expenses element, $K$, is given by a simple expression

$$K = \frac{C_{\text{fuel}}}{E\eta}$$

where $C_{\text{fuel}}$ is the specific cost of fuel used (that is the cost per unit mass of fuel), $E$ is the specific energy produced (the energy produced by the theoretical electrochemical reaction per unit mass of fuel), and $\eta$ is the working energy efficiency (the ratio of work done to energy put in, as defined in chapter 2) at maximum power.

Some simple conclusions are possible: as the lifetime of the installation increases, so $R$ decreases. $R$ also decreases when the rate of utilisation is high (that is, the working period is a large proportion of the year). $K$ depends inversely on the working efficiency of the plant. The measurement of $R$, $F$ and $K$ is in cost per unit power per unit time, and the conventional units are therefore pounds (or other appropriate currency) per kW h.

When the installation is not working at maximum power, it may be said to have a load coefficient, $f$, given by

$$f = \frac{P_{\text{actual}}}{P_{\text{max}}}$$