Overall electrochemical reaction inside a fuel cell system

$$H_2(fuel) + O_2(oxidant) = W + Q + H_2O(product) \quad E1$$

General electrical work

$$W = EI\Delta t \quad E2$$

The electrical work done in the fuel cell system

$$W = -nFE_{cell} \quad E3$$

The Gibbs free energy is the maximum amount of work done on the system.

$$W_{el} = \Delta G \quad E4$$

$$\Delta G = -nFE_{cell} \quad E5$$

The maximum cell potential or the reversible cell potential becomes

$$E_{rev} = \frac{\Delta G}{-nF} \quad E6$$

If all the potential chemical energy for a reaction went into electrical work and there was no heat transfer, there would be no entropy change; dG = dH. In this case, we can show that:

$$E_{rev} = \frac{\Delta H}{-nF} \quad E7$$

For a generic reaction or process

$$aA + bB \rightarrow cC + dD \quad E8$$

$$\Delta G_f = \Delta G_f^0 + RTln[\frac{aC^c aD^d}{aA^a aB^a}] \quad E9$$

To convert to voltage

$$E(T,P) = E^o - \frac{RTln\left(\frac{aC^c aD^d}{aA^a aB^a}\right)}{nF} \quad E10$$