Ex. 1 MCFC

Consider a molten carbonate fuel cell (MCFC) with an active area of 0.5 m^2 and an electrolyte's thickness of 1.5 mm.
At anode, it is fed with reformed natural gas, which is composed[1] by 50% H_2, 30% H_2O, 10% CO_2, and 10% of other gases (CO, CH_4, and N_2). A mix of 70% air and 30% CO_2 is injected at cathode.
The MCFC is analysed under the following operating conditions:
637°C, 1 atm, $\lambda_a = 2$ (air excess flow), 90%-*H_2-based* fuel utilization, 250 mA/cm^2.
Under these conditions, the cell voltage amounts to 0.75 V and the specific conductivity of the electrolyte is $\sigma = 0.4$ S/cm

Given these data and operating conditions, compute the:

1. Standard redox potential $E^{\ominus}$;
2. Redox potential at inlet E_{inlet};
3. Redox potential at outlet E_{outlet};
4. Ohmic loss of potential;
5. Non-ohmic (non-linear) loss of potential;
6. Electrical power;
7. LHV-based electrical efficiency;
8. Amount of water (liquid) produced each day.

Useful information:

To simplify the analysis, it can be admitted that only H_2 is subject to the electrochemical oxidation. Indeed, the kinetics of the "water-gas-shift" and of the "methane-steam-reforming" chemical reactions is rather fast in comparison with the electrochemical oxidations of CO and CH_4. Accounting also that the chemical equilibrium is displaced when H_2 is consumed, it leads that in presence of H_2O, CO and CH_4 are converted into H_2 and CO_2.

It can be admitted for simplicity that the average redox potential is: $E = 0.5\,(E_{\text{inlet}} + E_{\text{outlet}})$.

[1] Molar fractions. The actual composition of reformed NG depends on many parameters.