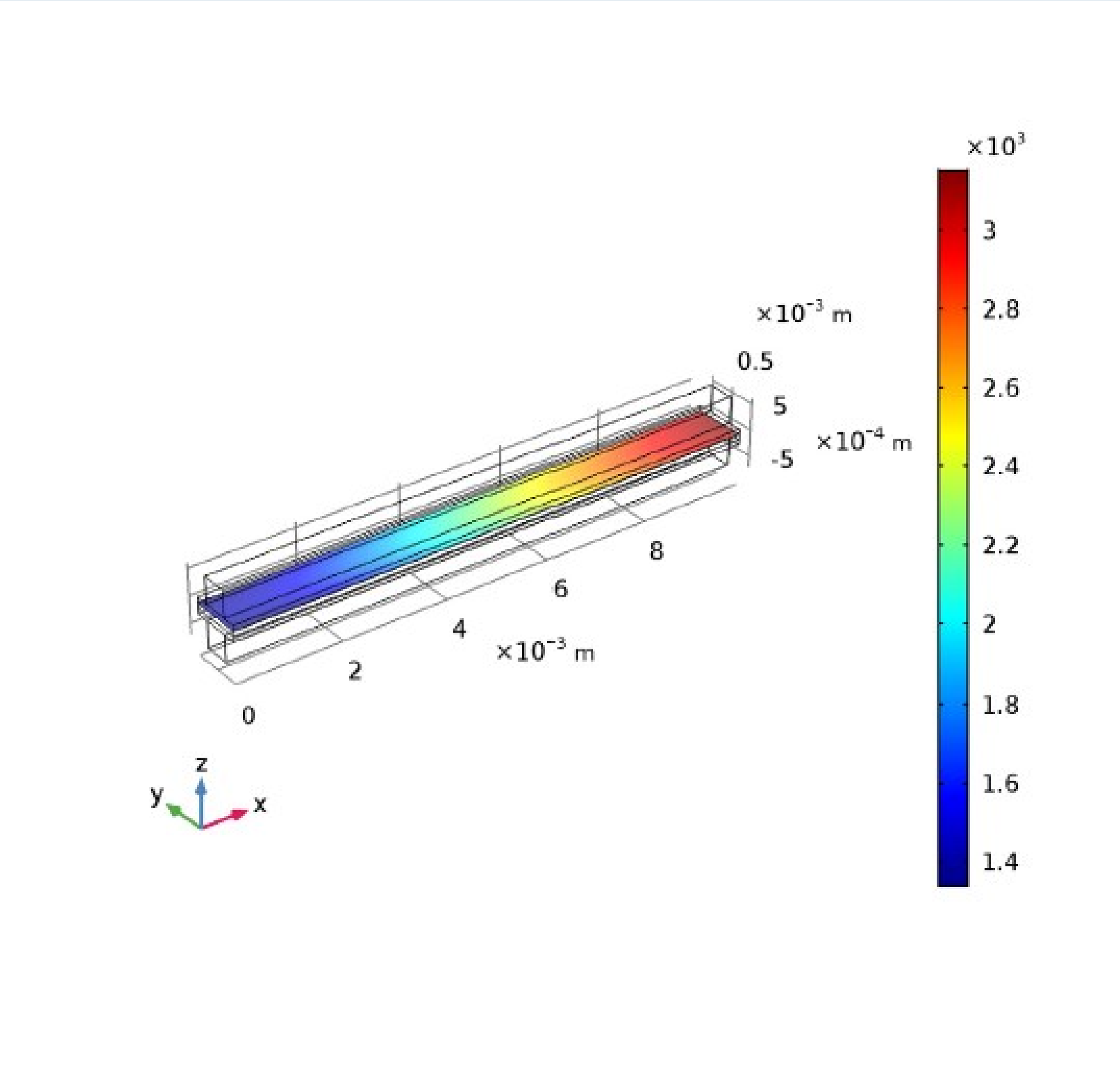

Performance analysis of a Solid Oxide Fuel Cell with two different parallel flow configurations

A model of an SOFC with two different flow configurations is set up in Comsol Multiphysics environment. It is used to analyze the SOFCs performances in the different flow configurations.

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Abstract

A Solid Oxide Fuel Cell (SOFC) can convert the chemical energy of a fuel (H_2-rich gas mixture [1] or syngas [2, 3] or biogas [4]) in electric and thermal energies with high electric efficiency. It is composed of two porous gas diffusion electrodes and an electrolyte (Figure 1). The fuel (a H_2-rich gas mixture) and air can enter in the fuel cell from the same side (co-current flows) or from the opposite sides (counter current flows) and the flow configurations affect the electrical performances in term of the polarization curves.

Solid oxide fuel cell systems fed by bio-methane can be integrated with electrical energy systems from renewable sources, lithium ion batteries and a proton exchange membrane (PEM) electrolyzer to obtain a poly-generative system capable of supporting pure electric or hybrid electric mobility with PEM fuel cells [5].
In this work, a model of an SOFC with the two different flow configurations is set up in Comsol Multiphysics 5.3 environment.

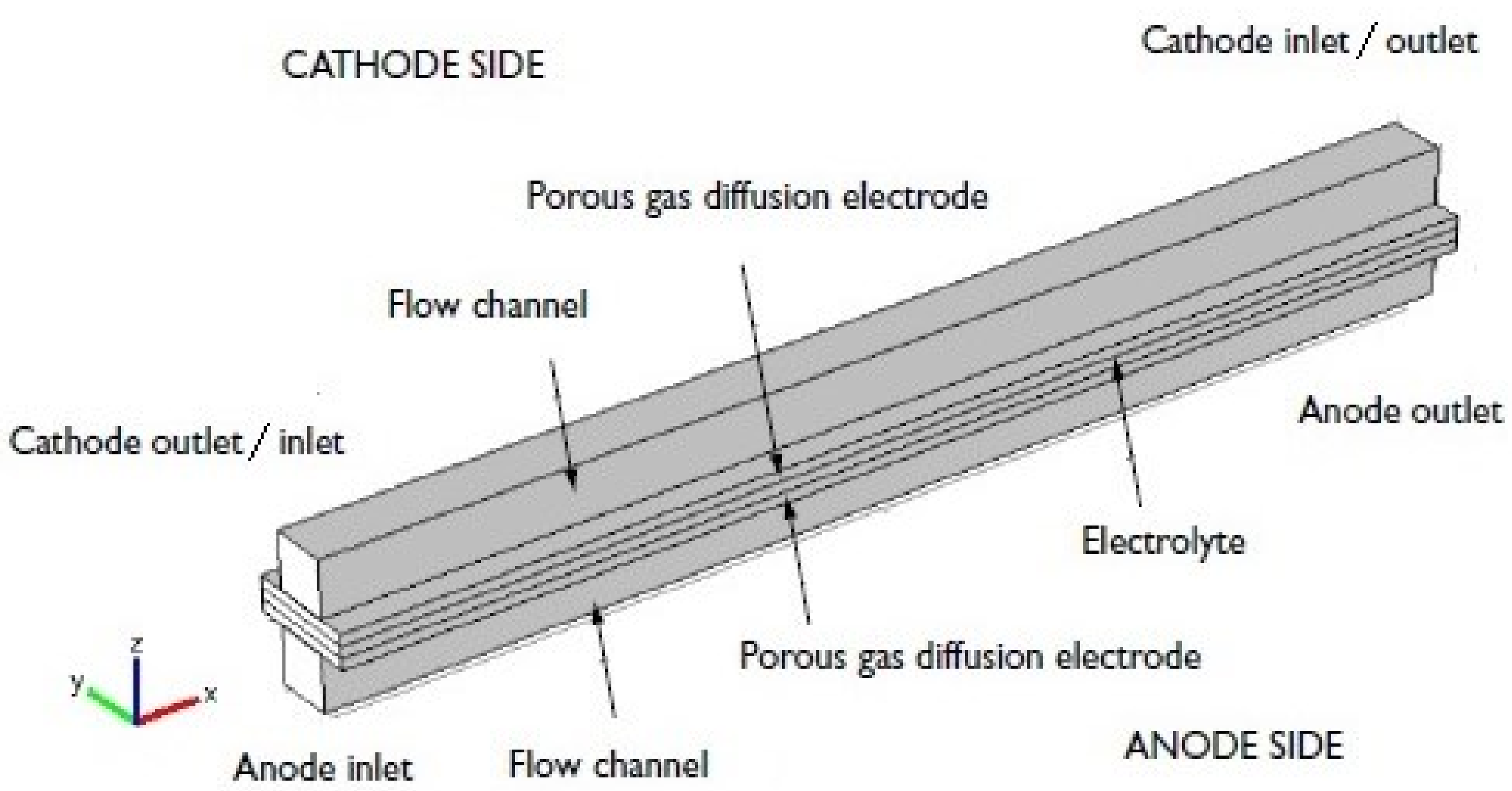

FIGURE 1. Model geometry

Methodology

The model includes the full coupling between the anode and cathode mass balances, the momentum balances in the gas channels, the gas flows in the porous electrodes, the ionic and electronic currents balances. It studies the performances of the SOFC with the two different flow configurations.
The model includes the following processes:

- Electronic charge balance (Ohm's law)
- Ionic charge balance (Ohm's law)
- Butler-Volmer charge transfer kinetics
- Flow distribution in gas channels (Navier-Stokes)
- Flow in the porous GDEs (Brinkman equations)
- Mass balances in gas phase in both gas channels and porous electrodes (Maxwell-Stefan Diffusion and Convection).

Results

The performance of a SOFC with the co- or equi-current flow configuration was better than the performance of the same SOFC with counter flow configuration.
Figure 2 shows that the cell voltage for the two flow configurations similarly decreases as the average current density increases. However, for the equi- or co- current flow configuration, the cell voltage is higher than that for the counter current flow configuration. In Figure 2 at about 2500 A m^{-2} the cell voltage is about 2.5 % higher in the equi- or co-current flow configuration than the other flow configuration, because in equi- or co-current flow configuration at each cell voltage the average current is higher than in other flow configuration in accordance with the results obtained in [8]. Therefore, the cell voltage and electric power are the highest in the equi- or co-current flow configuration in comparison with the other flow configuration. Therefore, these results show that the cell voltage can vary according to the flow configuration.

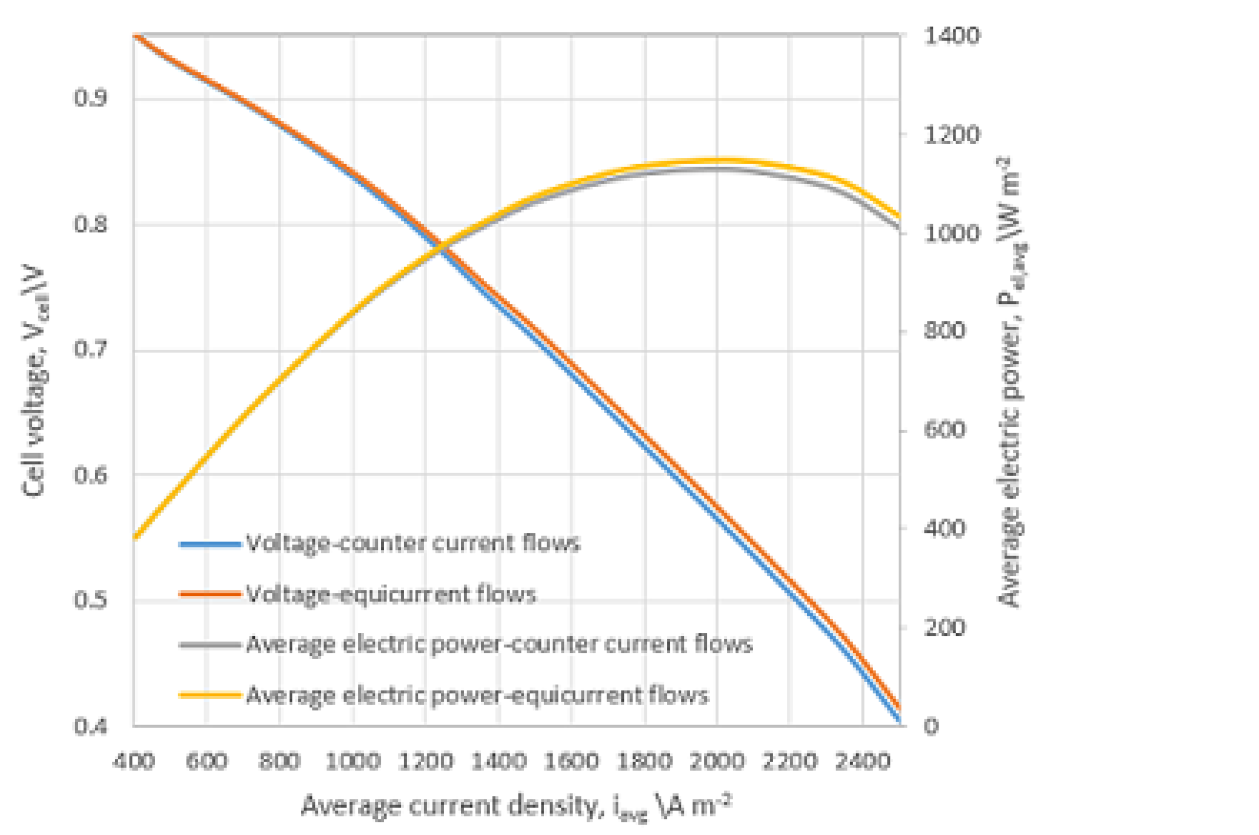

FIGURE 2. Polarization and average electric power curves of a SOFC with equi- or co- and counter current flows

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