SOEC/Electrolyzer Supplementary Model Details

Below details various parameters used in the electrolyzer model. Many parameters are the same as used in [1].

Table 1. Electrolyzer parameters.

Description	**Value**
Cell Length (m)	0.225
Cell Width (m)	0.1
Number of cells	534,857
Cathode flow channel height, h_C, (m)	1×10^{-3}
Anode flow channel height, h_A, (m)	1×10^{-3}
Interconnect height, h_I, (m)	5×10^{-4}
Height electric conducting structure, h_S, (m)	5.7×10^{-4}
Porous cathode thickness (m)	5×10^{-4}
Porous anode thickness (m)	2×10^{-5}
Electrolyte thickness (m)	5×10^{-5}
Interconnect heat capacity, $C_{p,I}$, (J/kg-K)	500
Electric conducting structure heat capacity, $C_{p,S}$, (J/kg-K)	500
Density of electric conducting structure, ρ_S, (kg/m^3)	5900
Density of interconnect material, ρ_I, (kg/m^3)	8000
Electric conducting structure thermal conductivity, λ_S, (W/m-K)	2
Interconnect thermal conductivity, λ_I, (W/m-K)	25
Porous cathode electric conductivity, (1/ohm-m)	8×10^{4}
Porous anode electric conductivity, (1/ohm-m)	8.4×10^{3}
Electrolyte electric conductivity, (1/ohm-m)	1.9
Electric conducting structure emissivity ϵ_S, (unitless)	0.8
Interconnect emissivity, ϵ_I, (unitless)	0.1

SOEC/Electrolyzer Control

The electrolyzer conversion is controlled based on a simple proportional-integral (PI) controller. The controller reads the measured H_2O conversion and compares it to the setpoint of 72.5% (which is the conversion for thermoneutral operation of the cell at design conditions found by trial and error) and then outputs an average current density, j_{avg}, to be applied to a single cell. The average current density then calculates the potential and conversion of the cell until the setpoint is reached.

SOEC/Electrolyzer Discretization

A cross section of the modeled SOEC is shown in Figure S1 below.

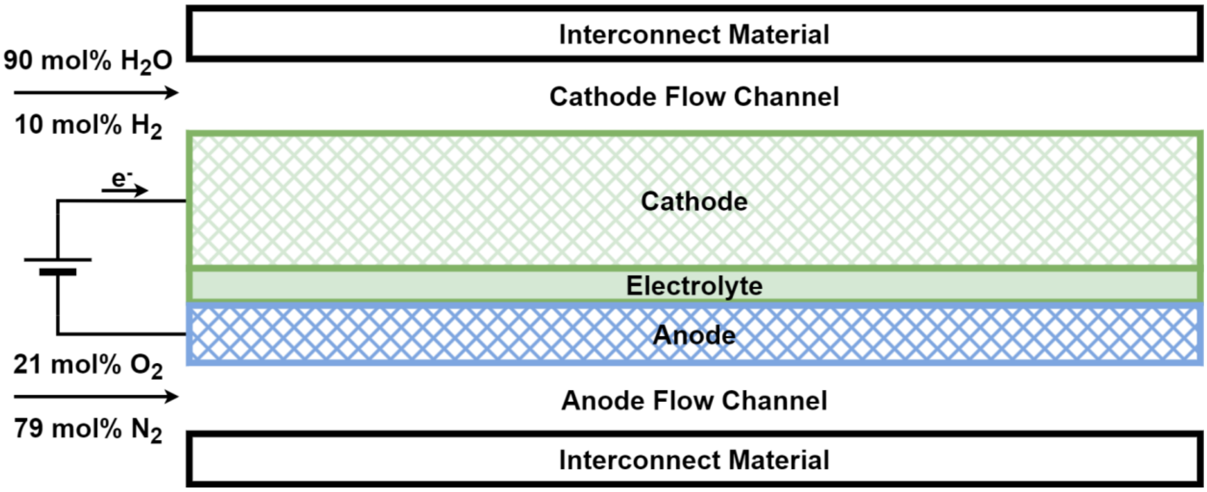

Figure S1. Cross section of the SOEC. Cell is discretized lengthwise down the direction of flow.

The SOEC cell energy and mass balances are PDEs which need to be discretized in space to form ODEs in time that MATLAB/Simulink can solve. The mass balances are discretized with a first order backward difference (looking upwind) for the first derivatives. The energy balance for the cathode and anode stream is also discretized with a first order upwind difference for the first derivatives. The interconnect material and the electric conducting structure include second derivatives for space and they are discretized with a first order backward difference (looking upwind).

Parabolic Trough Collector Supplementary Model Details

Full detail with parameters and more information is supplied in [2].

Heat Exchanger Supplementary Model Details

Each heat exchanger is sized by the number of cross flow passes, and total length of tubes (which defines size of a crossflow pass node). A diagram of one node for a heat exchanger is shown in Figure S2. Multiple nodes make up a heat exchanger.

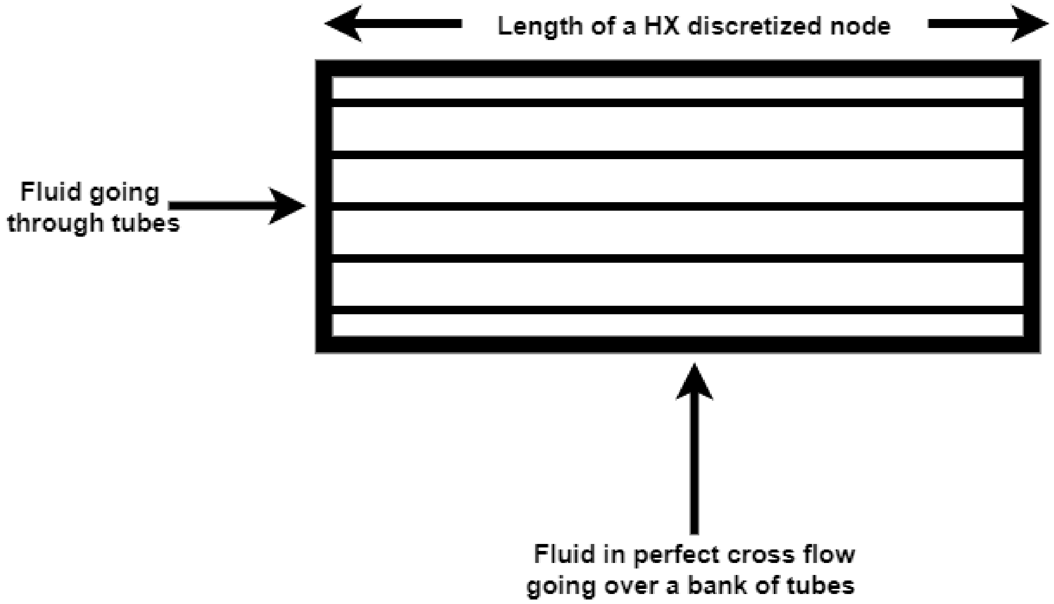

Figure S2. Heat exchanger node.

References

[1] J. S. Kim, R. D. Boardman, and S. M. Bragg-Sitton, “Dynamic performance analysis of a high-temperature steam electrolysis plant integrated within nuclear-renewable hybrid energy systems,” *Appl. Energy*, vol. 228, no. July, pp. 2090–2110, 2018, doi: 10.1016/j.apenergy.2018.07.060.

[2] J. Immonen and K. M. Powell, “Dynamic optimization with flexible heat integration of a solar parabolic trough collector plant with thermal energy storage used for industrial process heat,” *Energy Convers. Manag.*, vol. 267, no. June, p. 115921, 2022, doi: 10.1016/j.enconman.2022.115921.