

# Library for First-Principle Models of Proton Exchange Membrane Fuel Cells in Modelica

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This paper describes the architecture and key equations of FCSys, a library to model proton exchange membrane fuel cells (PEMFCs) in Modelica. The motivating goal of this work is to reconcile many of the published models of PEMFCs and combine them in a reconfigurable PEMFC model that is effective for a variety of uses. It is necessary to distill equations from fuel cell literature into forms that at once capture the essence of the physical interactions, are conducive to the physical modularity of the device, and work within the constraints and take full advantage of the Modelica language.

Since the behavior of PEMFCs depends on both advection and diffusion, a suitable alternative to the Modelica Fluid library and the stream concept is necessary. The proposed solution uses a “mixing” scheme based on the exponential of the Péclet numbers for each transport process. Storage and transport processes are co-located in each subregion of a rectilinear grid—all in the same base model. The Onsager formulation is used, whereby the effort and flow rate are conjugates of the entropy flow rate associated with energy transfer.

The implementation is modular. It allows species to be enabled independently for each region. In addition, the geometric axes may be independently enabled (up to 3D) and shearing (transverse momentum) may be optionally included. Chemical/electrochemical interactions are communicated in a fully acausal manner through expandable connectors.

This paper focuses on the motivation, background, and approach. Future publications will describe the ongoing work to calibrate, validate, and utilize the model for particular case studies. The library is made available as open source.

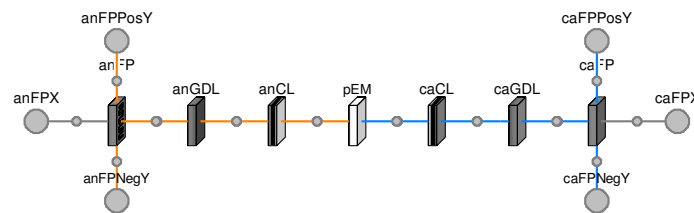


Diagram of a quasi-2D single-cell PEMFC

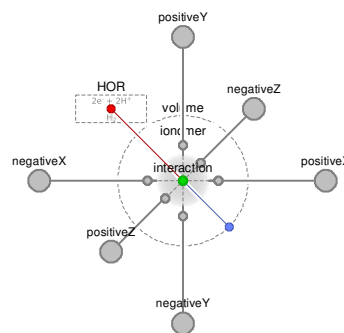


Diagram of a subregion