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Port-Hamiltonian Surrogate Modeling for Renewable Energy Systems

The increasing complexity of energy system models necessitates the use of surrogate models for efficient computation of optimal operations. In recent years, physics-based surrogate modeling has gained significant attention for its ability to enhance the accuracy of these surrogate models. However, applying surrogate modeling to complex networks introduces the challenge of system decomposition.
When reassembling the system after surrogate models have been identified, the resulting interconnected model may lose critical system-theoretic properties such as stability or passivity.

We utilize the port-Hamiltonian (pH) framework, which facilitates physics-based modeling and maintains structural interconnections. The pH approach is demonstrated in the context of sector-coupled energy systems, where the pH modeling approach is demonstrated for electricity, heat, and gas grids. We show how submodels of the components such as transmission pipes, storages or heat pumps can be identified from high-fidelity simulation data. These identified pH models are then integrated into a comprehensive pH system model, facilitating optimization of the overall operation of the system. Finally, we present a comparative analysis of the optimization outcomes for both the surrogate model and the high-fidelity model, evaluating their performance in terms of accuracy and computational efficiency.

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