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Ph.D. DISSERTATION DEFENSE

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Title:	Adoption, Impacts, and Interventions: Exploring Justice through Socio-Technical Dynamics in Household Energy Transitions
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ABSTRACT

Electricity has become an essential part of everyday life in the United States, influencing comfort, well-being, and daily routines nationwide. Yet the benefits and burdens of the electricity system are not shared equitably. Some households face higher costs, greater pollution exposure, and difficulty meeting basic energy needs, while others are better positioned to benefit from technological change. Many of these inequities are concentrated in the residential sector, where households regularly adopt, use, and replace technologies.

This dissertation explores justice in household energy transitions by tracing how adoption, impacts, and interventions shape those differences. It examines how socio-demographic and structural conditions inform residential technology adoption, how adoption patterns affect the magnitude and flexibility of electricity demand, and how electricity pricing and market design redistribute associated costs and benefits. To address these questions, the dissertation develops and applies an integrated framework that combines socio-technical systems theory, synthetic population generation, and agent-based modeling.

Across the analyses, household energy transitions emerge unevenly. Socio-demographic and structural conditions regulate who adopts residential technologies, when adoption occurs, and how technology configurations accumulate over time. The resulting differences carry forward into electricity demand, where similar proportional reductions can yield persistent disparities in annual and peak demand outcomes because baseline consumption and adoption timing vary across households. The intervention analysis further shows that market allocation rules can redirect greater financial benefits toward disadvantaged communities without increasing overall system costs.

Rather than treating justice as a separate outcome, the dissertation shows how socio-demographic, structural, and institutional conditions shape adoption, demand, and value in household energy transitions, and in doing so reveals dynamics that structure justice in the broader electricity system.