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MODELLING RESIDENTIAL CLEAN ENERGY TECHNOLOGY ADOPTION: AN OPEN-SOURCE, REUSABLE, AND SPATIALLY EXPLICIT AGENT-BASED MODEL

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Extended Abstract

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Abstract Summary

Accelerating adoption of clean energy technologies in the residential sector is critical to improve Europe's energy security without increasing climate risks. European households account for around 30% of energy consumption and emissions, and their reliance on oil and gas exposes them to volatile fossil fuel markets. Yet steering household adoption is a difficult policy challenge. Decisions are shaped by economic, behavioural, and social factors, and households differ widely in tenure status, income, and regional context, making one-size-fits-all policies inadequate.

Conventional energy models operate at high levels of aggregation and rely on simplified decision-making rules, which limits their ability to capture the micro-level dynamics of heterogeneous households. Agent-based models (ABMs) offer a promising alternative by representing individual agents, their decisions, and interactions. However, existing ABMs are typically tailored to local contexts, rely on non-public data, and lack open-source code, limiting their scalability, reproducibility, and policy relevance.

This paper presents an open-source, spatially explicit ABM of residential technology adoption with building-level resolution and flexible geographical scope. Household decision-making is grounded in the Theory of Planned Behaviour, capturing economic, behavioural, and social drivers. The model is built exclusively on openly available datasets and validated against historical adoption trends.

The model analyses heat pump adoption in Switzerland, where energy security, affordability, and decarbonisation challenges converge. Three policy experiments demonstrate capabilities beyond conventional models: combining information campaigns with subsidies, tailoring incentives for homeowners and landlords, and comparing spatially differentiated versus national policies. Results show that targeted and spatially differentiated policies influence uptake rates at lower policy costs, highlighting the need for

ABMs when assessing adoption policies. Our findings reveal how different regions and population groups respond to policies, informing strategies to improve energy affordability, equity, and security. This paper contributes to the growing need for open-source, reusable, and behaviourally realistic models to inform policy design.

Presenting Author Biography

Caterina Croci is a doctoral researcher in the Sustainability and Technology group at ETH Zurich. Her work focuses on developing a model that combines agent-based modeling and optimization techniques to simulate the effect of policies on adoption of residential clean energy technologies.

Caterina did her BSc in Mathematics in Italy and her master's in Computational Science and Engineering at ETH Zürich, where she focused her research on climate modeling and data analysis. Additionally, she has been working at a climate risk analytics start-up in Zurich (Correntics AG), where she was involved in data science, data analysis, and software development.