FORECASTING THE DIFFUSION OF RESIDENTIAL PHOTOVOLTAIC SYSTEMS IN AUSTRIA: AN AGENT-BASED MODELING APPROACH

Seif Marji, RWTH Aachen University, +4917643468886, seif.marji@rwth-aachen.de
Kagan Yüksel, Institute for Future Energy Consumer Needs and Behavior (FCN), School of Business and Economics / E.ON Energy Research Center, RWTH Aachen University, +49 241 80-49831, kagan.yueksel@eonerc.rwth-aachen.de
Reinhard Madlener, Institute for Future Energy Consumer Needs and Behavior (FCN), School of Business and Economics / E.ON Energy Research Center, RWTH Aachen University; Norwegian University of Science and Technology (NTNU), +49 241 80-49820, RMadlener@eonerc.rwth-aachen.de

Overview

By 2030, Austria aims at achieving 100% renewable energy in its electricity generation. Recent governmental policies and investments are accelerating the expansion of renewable energy production and utilization. Residential solar photovoltaic (PV) systems are expected to play a pivotal role in this transition. To better understand the future temporal and spatial diffusion of these systems, an agent-based model has been developed to identify key trends and assess the most effective policies influencing the adoption and diffusion of this technology. The model incorporates financial, social, and environmental factors to predict the national and regional diffusion trajectories of PV technology. [1]

Methods

The decision-making process for investing in a PV system is primarily driven by variables such as the payback period, environmental benefits, household income, and social interactions amongst agents. The proposed agent-based model calculates the payback period by considering investment costs, capital incentives, feed-in tariffs, savings from self-generated electricity, as well as administrative and maintenance expenses. Environmental benefits are assessed based on the proportion of household electricity consumption met by the PV system. Household income is modeled in relation to the agent's regional economic conditions and socio-economic characteristics, including age, education level, and household composition. Social influence is evaluated through the number of connections an agent has with households that have already adopted PV systems. [2]

The simulation is designed to dynamically adjust the population each year by excluding agents who have already adopted PV technology, rendering them ineligible for further adoption until the system's 25-year lifespan expires. [3] Furthermore, the simulation accounts for changes in household types and socio-cultural categories (Sinus-Milieus), ensuring that a limited number of agents remain available for adoption within each category. The model is calibrated using historical data on residential PV adopters from the period 2008-2023, and the results are extended to forecast the adoption rates over the 2024-2050 period. [4]

Results

The results indicate that, in line with long-term trends of decreasing PV system costs, and subsidy programs recently implemented by the Austrian government, adoption rates are projected to continue growing steadily through at least 2050. The analysis also examines how different scenarios—baseline, optimistic and pessimistic—affect adoption rates over time. By analyzing technological cost reductions and policy incentives, including capital incentives and feed-in tariffs, the results indicate the importance of future price reduction trends to accelerate adoption, as well as the short-term and long-term effects of policy as illustrated in Figures 1 and 2.

Conclusions

House owners, due to their higher disposable incomes, greater access to rooftop space, and more favorable regulations, have emerged as the primary adopters of PV systems. This is particularly evident in regions with higher home ownership rates, such as Lower Austria and Upper Austria. In contrast, areas with lower rates of home ownership, such as Vienna, initially experienced slower adoption. However, as PV prices decline and payback periods shorten, adoption rates in urban areas are expected to rise. Households with lower electricity consumption have also shown delayed investment in PV systems, influenced partly by lower electricity bills and specific government subsidies.

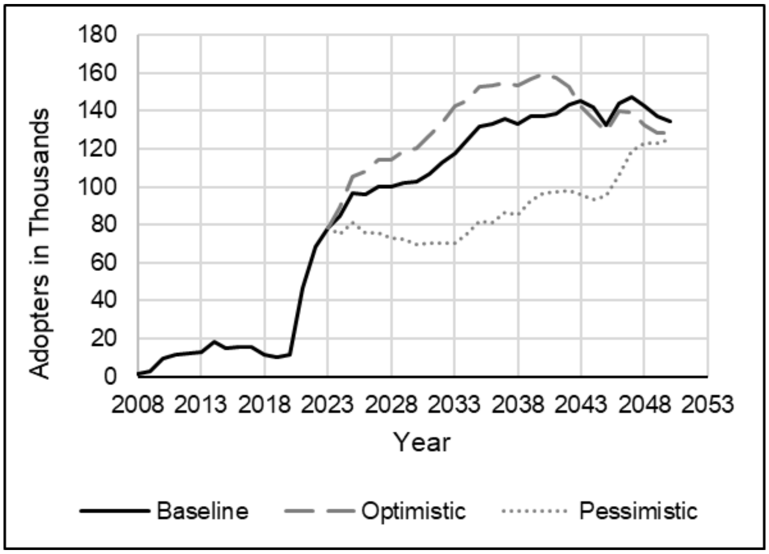

Figure 1: Scenario Analysis of Adoption based on Future PV System Price

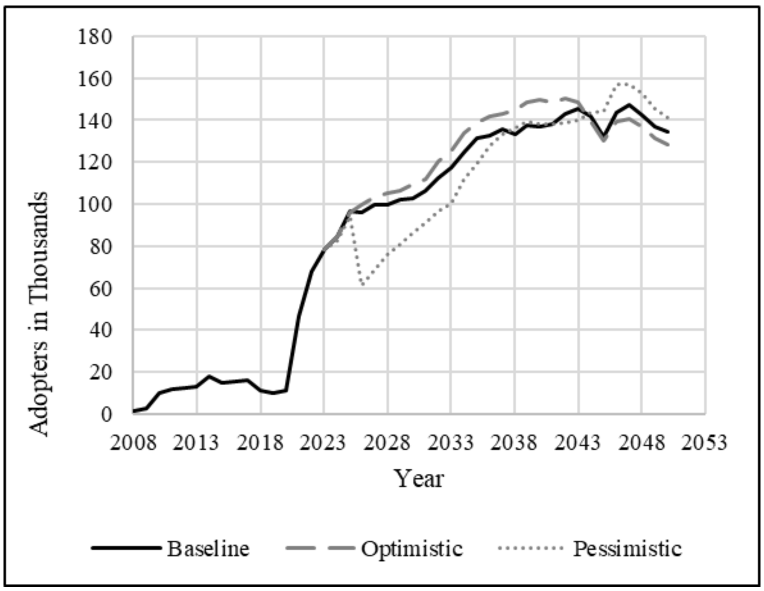

Figure 2: Scenario Analysis of Adoption based on Future Incentives

References

[1] Biermayr, P. (2023). *Innovative Energietechnologien in Österreich Marktentwicklung 2022*. Bundesministerium: Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie.

[2] Marji S., Yüksel K., Madlener R. (2024). Forecasting the Diffusion of Residential Photovoltaic Systems in Austria: An Agent-Based Modeling Approach, FCN Working Paper No. 19/2024, Institute for Future Energy Consumer Needs and Behavior, RWTH Aachen University, (in prep.).

[3] Palmer, J., Sorda, G., & Madlener, R. (2015). Modeling the diffusion of residential photovoltaic systems in Italy: An agent-based simulation. *Technological Forecasting and Social Change*, 106-131.

[4] PV Austria. (2023). *Photovoltaische Zellen*. Von Photovoltaik Austria: https://pvaustria.at/technische-grundlagen/ abgerufen

[5] SINUS. (2022). *Sinus Milieus Austria*. Von https://www.sinus-institut.de/en/sinus-milieus/sinus-milieus-oesterreich abgerufen