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Das Energiesystem nach Corona: Irreversible Strukturänderungen - Wie?

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# Agent-based model of net-zero integrated retrofitting of neighbourhoods

Energie in Gebäuden
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## Motivation and Aims

The current rate (0.4-1.2%) and depth of building retrofitting across Europe are insufficient to achieve the Paris agreement [1]. New approaches are necessary to accelerate the process of retrofitting. Mass retrofitting using prefabricated facades and roofs [2] to net-zero energy performance, combined with innovative business models (performance guarantee in „Energiesprong“ [3], offer of integrated retrofitting packages by One-Stop-Shops [4,5], group purchases of retrofitting materials [6]) can be a promising solution. However, there are many open questions, one of those being: What socio-techno-economic conditions facilitate the diffusion of net-zero retrofitting packages among building owners in a neighborhood? The article is the first attempt in developing the agent-based diffusion model that will attempt to answer this question.

## Methodology

Agent-based model (ABM) is a computer simulation of an artificial world populated by agents – discrete decision-making entities (individual, household, firm, etc.). ABM allows to incorporate heterogeneity and adaptivity of energy consumers [6] and is well-suited for modelling the complex interactions between heterogeneous agents with different goals and characteristics [7]. The realisation of integrated net-zero energy retrofitting that we want to analyse is an example of such complex multi-stakeholder systems (see Figure 1).

The conceptualisation and implementation of an agent-based model is known to be challenging. Moreover, there are very few agent-based models related to energy-efficient retrofitting [8,9]. Therefore, we will first conduct a small literature review to learn: (a) how ABM has been used to study energy-efficient retrofitting; (b) how building owners‘ decisions regarding retrofitting is modelled. Then, based on the previous conceptual model presented by the authors [10], we describe how our ABM of net-zero retrofitting decisions functions, including who the agents are, what actions they perform based on what „rules“ and parameters, and how the simulation outcomes are evaluated. Finally, a basic model will be implemented using Python Mesa (i.e. package for agent-based simulation).

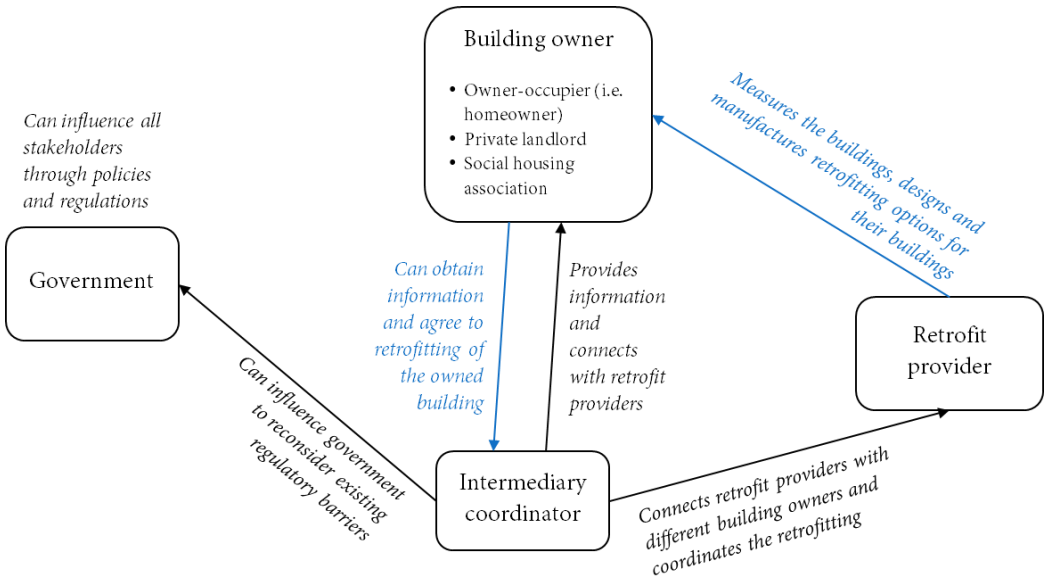


*Figure 1. Relationships of the key stakeholders*

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## Results and Discussion

In the ABM of net-zero retrofitting, „intermediary agents“ inform the building owners in one neighborhood about the opportunity to retrofit their dwellings. Building owners can choose a retrofitting package based on their „decision-making framework“ (i.e. rules, algorithm) that considers the factors that influence their (investment) decisions regarding retrofitting (e.g. capital investments, perceived payback period, other non-monetary benefits). Retrofitting packages will be identified using the sub-model „techno-economic evaluation of retrofitting packages“ based on the existing building archetypes of the Tabula project [11]. The retrofitting options will be clustered to three main groups: a) building envelope insulation; b) heating system improvements; c) renewable energy generation and storage system installation.

Several scenarios of policy interventions (e.g. changes to regulatory framework of housing, CO2-taxes) will be investigated. Moreover, sensitivity analysis with regards to techno-economic conditions (energy prices and/or CO2-prices, building energy efficiency and type of the building, costs of retrofitting solutions) and socio-economic characteristics in the neighbourhood (building owner's age, education, income, environmental awareness/attitude, ownership/tenure status, etc). The results will show the number of adopters, the retrofitting solutions adopted, energy and emissions saving achieved, and the annual renewable energy generation. The preliminary flow-chart of the simulation is displayed in Figure 2.

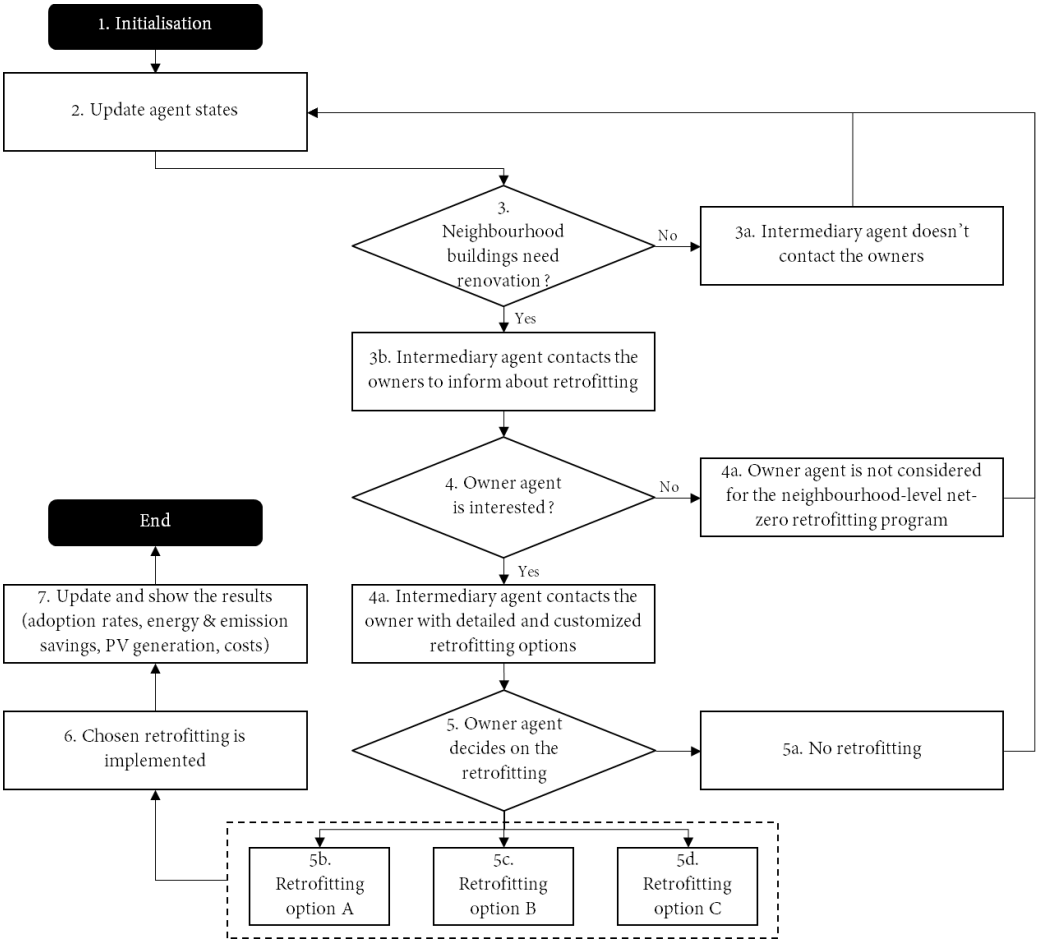


*Figure 2. Simulation flowchart*

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