

# Are energy decisions about energy?

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## Summary

The transition to a low-carbon housing stock must increase more rapidly to meet the European climate goals: 55% reduction of greenhouse gasses in 2030 and becoming climate neutral in 2050. This transition can be realised by implementing residential low-carbon measures such as insulation, high-efficiency glazing, efficient heating and ventilation systems, and residential renewable energy production such as photovoltaics. Despite the urgency of climate change, the housing market remains reluctant to innovate toward a low-carbon housing stock. The current slow adoption rate of low-carbon measures in the housing stock can be attributed partly to the fact that energy policies generally disregard the diversity of concerns and motivations of homeowners and often rely on a generic approach instead. However, homeowners' choices about low-carbon measures are affected by a range of considerations, motivations, and contextual elements that require a holistic and comprehensive understanding. This deeper understanding is necessary to enhance the impact of energy policies and offer more tailored advisory services to consultants and energy coaches to ensure the effectiveness of their work. The Netherlands has a total of eight million homes, of which 57.1% are owned by private homeowners, 28.8% are owned by social housing associations, and 12.8% are owned by commercial and private landlords. For the purpose of this thesis, the focus will be on the first two as they account for the majority of the Dutch housing stock.

To boost the implementation of residential low-carbon measures, an in-depth understanding of homeowners' decision-making processes is needed. However, previous research has revealed limited insights into the factors influencing the various decision-making stages. Moreover, homeowners' heterogeneity in terms of their personal characteristics and how they influence their decision-making process is poorly understood or provides inconclusive results. Justice aspects of the decision-making process regarding residential low-carbon measures are also understudied. Justice aspects are related to the fairness in the way people are dealt with. These issues are of particular importance in social housing, which typically is home to many vulnerable households. Furthermore, prior studies have demonstrated that formal and informal intermediaries can play a significant role in enhancing decision-making, but only a few studies have examined intermediation between the supply and demand side. Overall, this lack of knowledge of the factors influencing homeowners' decision-making processes can hamper the uptake of residential low-carbon measures.

The research in this thesis aims to identify and evaluate the varying factors that influence the multistage decision-making processes of homeowners regarding residential low-carbon measures. The thesis focuses on the Netherlands, which has

a long history of policy efforts initiated since the late 1970s to stimulate residential low-carbon measures, but diffusion of these measures has lagged. Additionally, this thesis examines owner-occupied and social housing, as they account for the majority of the Dutch housing stock. The aim of this research is to deepen the understanding of this topic to gain a more comprehensive and holistic understanding of homeowners' decision-making processes and how they can be enhanced. Hence, the main research question is:

*What factors influence the decision-making processes of Dutch homeowners regarding residential low-carbon measures, and what interventions can encourage them to do more?*

The socio-technical analysis highlights the contextual circumstances of people; their needs, concerns, and ways of thinking and evaluation; differences therein; justice aspects; the role of intermediation; and influences from others (professionals and non-professionals). To address the main research question, this research consists of four empirical studies. A mixed-methods approach was used, which combined quantitative and qualitative data to collect and analyse the data. The four studies and their sub-research questions are discussed in the following sections.

In the first study, the influencing factors in the various stages of the decision-making process of private homeowners concerning renovation measures were investigated using the adoption and diffusion literature. Private homeowners were chosen, as they comprise more than half of Dutch residential property owners. Data were collected through surveys and interviews with private homeowners in the city region of Parkstad Limburg (NL). As part of the study, a novel integrative model of private homeowners' decision-making processes about energy renovation measures was developed. The model differentiates between the various decision-making stages, the factors that influence these stages, and the many considerations homeowners face when deciding whether to invest in energy renovation measures. The study results reveal that a variety of factors are relevant at different stages of decision-making. At the 'getting interested' stage, external developments, physical factors of the dwelling, socio-demographic factors, and environmental concerns can trigger an interest in energy renovation measures. At the 'gaining knowledge' stage, homeowners gain knowledge about the measures, and personal background and advice from their social network or from professionals can influence the decision process. At the 'forming an opinion' stage, homeowners form an opinion about the energy renovation measures and in this stage financial-economic factors are particularly important. In the 'making a decision' stage, they decide whether to adopt the measures. After implementing the

measures, homeowners can also influence others in their social network and become ambassadors for further energy-saving changes in the 'experiencing' stage. Future policy interventions should, therefore, address the specific barriers at each decision stage to increase the uptake of energy renovation measures by private homeowners.

In the second study, the outcomes of the first study were used to gain further insights into the heterogeneity of potential residential photovoltaic adopters via a segmentation mode for designing targeted communication policies. Data were collected through a survey of Dutch adopters, and the data were analysed with statistical descriptive analyses and non-parametric tests. The five segmentation groups are divided by homeowners' educational background or profession (technical, financial-economic, or other) and level of environmental concern. The results demonstrate that the groups differ significantly in the homeowners' level of environmental concern and the level of influence of their social network on their decision to adopt. Moreover, the groups differ significantly in their perceptions of the complexity and aesthetics of the photovoltaic system and their prior experience with other home energy measures. These insights can be used by policymakers and the public and private sectors to more effectively promote residential photovoltaics by adequately targeting the specific characteristics of the various segmentation groups. The groups will be drawn to different aspects, and therefore, (1) a broader range of benefits must be presented, (2) a mix of different communication channels must be used, (3) objective and non-technical assistance in decision-making must be offered, and (4) different products must be provided to target a broader audience.

The third study investigated what justice aspects affect energy renovations in social housing and how a better understanding of this can be used to achieve outcomes that are more socially fair and just for tenants. This priority is not always valued at this time. Approximately one third of the Dutch housing stock is owned by social housing associations which make them a crucial sector to address. The study examines the impact of a multidimensional justice perspective on energy renovations in social housing and how this knowledge can be applied to achieve more beneficial outcomes for tenants. Justice in the context of energy renovations in social housing is a topic that has been understudied in the past. The five dimensions of justice are distribution, recognition, participation, capability, and responsibility. The topic was, therefore, explored in this study by interviewing employees and members of Dutch social housing and tenant associations to gather their experience and perspectives. This study demonstrates that a more pluralistic justice approach is needed in the transition to a low-carbon social housing stock and that the multidimensional justice perspective can be applied to implement a broader perspective of justice principles. These insights can be a starting

point for achieving a more just energy renovation process in social housing, especially by addressing the needs of vulnerable households. Moreover, the results reveal that all five dimensions are imperative to consider at all stages of this renovation process; they are strongly interlinked and should not be addressed separately.

The fourth study examined how intermediation affects the multistage decision-making process about building-integrated photovoltaics in the Netherlands and how it can be improved. Intermediation is the act of connecting or brokering between individuals or organisations. Several challenges hinder this emerging technology, such as information asymmetry and limited value chain coordination. As demonstrated in previous studies, intermediaries can play a crucial role in managing these challenges, but this aspect has not yet been examined in depth for this technology. Moreover, there is a lack of insight into intermediaries positioned between the supply and demand sides. A comprehensive overview of various intermediaries' abilities to facilitate the multistage decision-making process is lacking. Instead of focusing on specific intermediary actors, the Dutch system for building-integrated photovoltaics is investigated by identifying which actors act or can act as intermediaries and what intermediation activities can help with decision-making. The study combined both innovation and intermediation perspectives to collect and analyse the data, and the results demonstrate that intermediation is essential at every stage of the decision-making process. A dynamic 'ecology of intermediaries' is recommended to perform various intermediation activities at different system levels in the multistage decision-making process. As these activities and actors are highly interrelated and interdependent, it is argued that it is crucial to assess intermediation in a holistic way, as it demonstrates that intermediation is an interrelated, multilevel, and varied phenomenon. These findings are useful for suppliers, potential intermediaries, and governments because they can support the decision-making process with the help of intermediation.

In conclusion, this thesis offers a socio-technical analysis of homeowners' energy decisions, demonstrating that relevant decisions are not isolated choices but are situated in daily life with multiple decision moments and dynamic circumstances. The thesis reveals that homeowners' decisions on the adoption of residential photovoltaics, building-integrated photovoltaics, and other residential low-carbon measures are influenced by a variety of factors. These decisions are shaped by homeowners' heterogeneity, embedded in social practises, affected by justice aspects, and encouraged by intermediation activities. The research moves beyond socio-technical systems analysis by considering the decision-making processes of heterogeneous actors in much more detail and by highlighting justice aspects and the details of intermediation. Many actors can utilise this knowledge, including policymakers, employees and members of

social housing and tenant associations, suppliers, consultants, energy coaches, and architects. By understanding these insights, low-carbon policies, internal procedures, advice to homeowners, and communication campaigns can be enhanced to increase the diffusion of low-carbon technologies. Overall, energy decisions are not only about energy but are influenced by a variety of factors and dynamic circumstances.