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Planning home energy retrofit in a social environment: The role of perceived descriptive and injunctive social norms

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ABSTRACT

In the built environment, improving the energy efficiency of existing building stock through retrofitting is the top pillar to mitigate climate change. Despite the efforts made by local authorities to provide technical and financial supports, the home energy retrofit rate remains low. This study aims to improve the understanding of how homeowners make their energy retrofit plans in a social environment, thereby informing behavioural policy (re)design. Using a sample of inexperienced retrofitters among Dutch homeowners (N = 556), we investigate the relationship between perceived social norms and energy retrofit plans. The results show that homeowners who perceive a positive injunctive norm have an 11.8 percentage point higher probability of making a home energy retrofit plan compared to those with a non-positive perception. Perceived injunctive norms are also significantly associated with the number of planned retrofit measures and aligned with multiple direct barriers and motivations for retrofitting. However, perceived descriptive norms are only associated with the number of planned retrofit measures, and are even correlated with stronger perceived barriers. We conclude by discussing different social influence pathways of descriptive and injunctive norms, as well as the potential of leveraging social norms as a behavioural policy intervention to promote home energy retrofit.

1. Introduction

Improving energy efficiency has long been recognised as a successful and cost-effective strategy to reduce energy demand (IEA, 2023), and eventually mitigate climate change. As part of the global roadmap towards net zero emissions, comprehensive retrofitting can enable 20% of the existing building stock to be zero carbon-ready[1] by 2030, and achieve a rate of 50% by 2050 (IEA, 2022). In line with the global trajectory, the Netherlands has set the goals of reducing carbon emissions by at least 55% by 2030 and achieving climate neutrality by 2050. To accomplish these goals, various measures have been proposed, including home renovation programmes with the aim of insulating an average of 150,000 homes per year (PBL & ECN, 2011). However, in spite of the dedicated efforts made by local authorities to provide technical and financial supports, the energy retrofit rate of owner-occupied homes remains low (Ebrahimigharehbaghi et al., 2022).

In order to address homeowners' reluctance towards home energy retrofit and inform policy design, it is crucial to first understand the factors driving retrofit decisions. Among the various factors identified by Broers et al. (2019), this study specifically examines the role of social norms. Individual behaviours in the built environment are inseparable from the social context (Abreu et al., 2019; Dean et al., 2016; Rajaee et al., 2019). Within a social context, individuals tend to conform to social norms, including the norms that imply social approval (i.e., injunctive social norms) and those that indicate the predominant behaviours (i.e., descriptive social norms) (Cialdini et al., 1990; Frederiks et al., 2015). Although the impact of social norms on daily energy conservation has been extensively explored in research and leveraged by real-world behavioural policy interventions, the role of social norms in energy retrofit decisions remains relatively unexplored (Wolske et al., 2020).

In contrast to the curtailment of daily energy use, home energy retrofit measures (e.g., solar panels) and their implementation process (e.g., improving window insulation) are highly visible from the outside. Furthermore, home energy retrofitting is a more complex process, which requires substantial upfront investments and involves multiple decision stages (Broers et al., 2019; Klöckner & Nayum, 2016; Wolske et al., 2020). As a result, making the decision to retrofit one's home can rely mainly on cognitive deliberation rather than decision heuristics (Taranu et al., 2017; Wolske et al., 2020). Considering these

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[1] A zero carbon-ready building can be fully decarbonised by directly using renewable energy or through a clean energy supply (IEA, 2022).

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characteristics, we anticipate that social norms related to home energy retrofit can influence the decision-making of potential retrofitters, albeit through pathways that differ from simpler curtailment behaviours.

This study aims to shed light on the role of social norms in complex home energy retrofit decisions by answering two main research questions: (1) How are social norms related to homeowners' decisions about whether to undertake energy retrofitting and the depth of retrofitting in the future? (2) How are social norms related to direct motivations and barriers to home energy retrofit? With a large-scale household survey of Dutch homeowners, we addressed these questions by investigating the relationships between perceived social norms, i.e., subjective beliefs about social norms, and multiple variables pertinent to home energy retrofit plans, including whether to undertake retrofitting, the depth of retrofitting, as well as the stated motivations and barriers that directly drive homeowners' decision-making.

Our findings reveal several insights. First, perceived injunctive social norms are positively associated with both the probability of making a home energy retrofit plan and the number of planned retrofit measures. However, perceived descriptive social norms only exhibit a positive association with the latter, more precise measure of retrofit plans. Second, positive perceived injunctive social norms are linked to a greater number of direct motivations for home energy retrofit compared to perceived descriptive social norms. Third, positive perceived injunctive social norms generally predict a low level of self-evaluated barriers to energy retrofit. However, perceived descriptive social norms are positively correlated with the extent of several perceived barriers such as concerns regarding costs, as well as the hassles in finding grants and consultants. Based on these empirical findings, we propose potential social influence pathways of injunctive and descriptive social norms. Specifically, the social influence of perceived injunctive social norms might be normative in nature, characterised by a strong pursuit for social approval. Perceived descriptive social norms may be indicative of careful deliberation, and thus suggest an informational social influence. To the best of our knowledge, this study is the first to attempt to distinguish the roles of descriptive social norms and injunctive social norms in the context of home energy retrofit. In addition, this study contributes to the broader literature on social influences and home energy retrofit decisions (e.g. Bollinger et al., 2022; de Wilde, 2019; Noll et al., 2014).

This paper proceeds as follows. Section 2 reviews relevant literature on social norms, social influence pathways, and their relevance to home energy retrofit. Section 3 describes the survey questionnaire and the sample. Results are presented in Sections 4 and 5 and are discussed in Section 6. Section 7 concludes and proposes policy implications.

2. Social norms and home energy retrofit decisions

A main strand of literature exploring how household energy behaviours are shaped in social environments revolves around the concept of social norms (Wolske et al., 2020). Social norms can be defined as rules of conduct that are "shared by other people and partly sustained by their approval and disapproval" (Elster, 1989, p. 99). In the field of household energy use, several psychological mechanisms have been proposed to explain the behavioural impacts of social norms. These mechanisms include drawing attention to energy consumption (Zhou, 2020), addressing biased beliefs about others' energy use (Bartke et al., 2017), establishing a salient reference point and appealing to reference-dependent preferences (Andor & Fels, 2018), promoting normative conformity (Cialdini & Goldstein, 2004; Farrow et al., 2017), fostering competition (Farrow et al., 2017; Festinger, 1954), and activating pro-social and pro-environmental values (Bonan et al., 2021; Fanghella et al., 2020).

Within the realm of social norms, a prominent distinction has been made between descriptive social norms, indicating what is commonly done by most people, and injunctive social norms, signalling what is approved or disapproved by most people (Cialdini et al., 1990). Proceeding from the definition, these two forms of social norms diverge in the motivational forces that drive individual behavioural adaptation, namely the desire for accurate and efficient decisions versus the pursuit of social approval (Jacobson et al., 2011). Specifically, descriptive social norms provide individuals with evidence of likely effective and adaptive actions, which can facilitate information processing and serve as a decision heuristic, thereby reducing the cognitive costs associated with deliberation (Cialdini et al., 1990; Farrow et al., 2017). Unlike descriptive social norms, injunctive social norms influence individual behaviour by signalling social rewards and sanctions based on the approval or disapproval of others (Cialdini, 2003; Cialdini et al., 1990).

According to the focus theory of normative conduct, creating an injunctive norm focus on social disapproval can generally be effective, whereas the effectiveness of a descriptive norm focus depends on the prevalence of the desired or undesirable behaviour within the social group (Cialdini et al., 2006, 1990). Furthermore, an empirical study of environmental public service announcements by Cialdini (2003) showed that the intention to recycle was influenced by the injunctive normative information through its impact on the perceived persuasiveness of the announcements, while the descriptive normative information directly influenced the intention. This finding suggests that descriptive social norms exert a direct influence on behaviour with little cognitive analysis, whereas injunctive social norms require an understanding of the moral rules within the group, thereby influencing behaviour through a reasoned channel (Cialdini, 2003; Wolske et al., 2020).

To gain a comprehensive understanding of the underlying mechanisms, the role of social norms can be placed within the broader discussion of social influence, which encompasses two primary routes: normative social influence and informational social influence (Deutsch & Gerard, 1955). While normative social influence occurs when individuals conform to the positive expectations of others, informational social influence arises when individuals are influenced by information on others' behaviour as evidence about reality.[2] These two social influence pathways are aligned with the motivational forces underlying descriptive and injunctive social norms (Göckeritz et al., 2010). The desire for social approval that underlies injunctive social norms corresponds to normative social influence. Descriptive social norms can operate through both normative and informational social influence pathways.

In the field of household energy behaviour, the impacts of social norms on daily energy conservation have been well-documented. Interestingly, although people stated that social norms were not an important determinant for them to save energy, both self-reported perceived social norms and interventions with social norms were found to be strongly related to households' conservation behaviour (Nolan et al., 2008).

For over a decade, social norms have been leveraged as a behavioural policy instrument to promote energy conservation of households (e.g., Allcott, 2011; Allcott & Rogers, 2014; Andor et al., 2020; Bonan et al., 2020, 2021). As a standard design, this behavioural policy instrument takes the form of a home energy report, which generally includes a descriptive norm that indicates a household's energy performance relative to that of peers, an injunctive norm that conveys social approval of one's energy consumption, and energy-saving tips. Several studies investigated the different impacts of descriptive and injunctive social norms provided in home energy reports. One of the earliest studies in this field found that while descriptive norms effectively reduced energy consumption among high energy users, it paradoxically increased consumption among low energy users, which is known as the boomerang effect (Schultz et al., 2007). In other words, the descriptive norm was found to increase the consumption of households that use less energy than their peers. However, this undesirable effect can be

[2] Note that in some recent environmental and energy studies (e.g., Bergquist & Nilsson, 2016; Nolan et al., 2008), normative social influence also refers to the influence caused by social norms in general (Bergquist & Nilsson, 2016).

counteracted by including an injunctive normative message. Subsequent investigations have revealed a more nuanced role of injunctive social norms in mitigating the boomerang effect. Allcott (2011) showed that manipulating different categories of injunctive norms did not significantly affect the treatment effect, suggesting that injunctive social norms might mitigate the boomerang effect to a similar extent across user categories. Moreover, Bonan et al. (2020) provided experimental evidence that descriptive and injunctive social norms operate in a complementary rather than substitutable manner. When the two types of social norms were aligned (e.g., both norms encouraged energy conservation among high energy users), the effectiveness of the feedback was enhanced; conversely, when the two types of norms conflicted (e.g., among low energy users, descriptive norms implied increasing consumption while injunctive norms encouraged conservation), the combined effect was determined by their relative strengths. Similar patterns have been observed for perceived social norms,i.e., subjective beliefs about social norms. In a survey study, Göckeritz et al. (2010) found that self-reported conservation behaviour was more frequent when both perceived descriptive and injunctive social norms were high. Furthermore, they identified a non-conscious influence process of perceived descriptive social norms based on the fact that the positive relationship between conservation behaviour and perceived descriptive social norms diminished when individuals had a high level of conscious personal involvement in energy-saving activities.

Despite the extensive research on social norms and conservation behaviour, there has been relatively little focus on the role of social norms and energy-efficiency investment decisions (Wolske et al., 2020). Whether and through which channels social norms influence investments in energy-efficient appliances and retrofit measures remain largely unexplored. On the one hand, many energy-efficiency investments, particularly major measures such as window insulation and rooftop solar panels, are highly visible to others, which is closely tied to social identity and provides an opportunity for social influence to occur (Abreu et al., 2022; Bollinger et al., 2022). On the other hand, as mentioned above, these investment decisions are complex and typically involve careful deliberation rather than decision heuristics, suggesting that passively observing peer behaviours may have limited influence (Taranu et al., 2017; Wolske et al., 2020). Given these considerations, social norms can affect household decision-making about home energy retrofit through multiple pathways (Wolske et al., 2020). First, the high visibility of energy retrofit measures, such as solar panels, enables the formation of descriptive social norms, which can trigger intuitive responses. As households become more attentive to these measures and adapt to social preferences, the retrofit rate can increase. This pathway aligns with the normative influence exerted by descriptive social norms. Second, both descriptive and injunctive social norms can communicate the value of energy conservation and the social approval of energy retrofit, thereby exerting normative social influence. Third, social norms, along with interpersonal communication, can facilitate decision-making processes by promoting information exchange and reducing uncertainties regarding the benefits of energy retrofit measures. This third pathway operates through informational social influence.

A few studies have examined the role of social norms in the adoption of energy retrofit measures. By analysing a large data set of 820,474 homes in total and 17,291 solar adopters in the US, Bollinger et al. (2022) found that solar panel installations in the neighbourhood increased the probability of subsequent adoption by peers. However, the strength of this positive peer influence was contingent upon the visibility of the solar panels, with stronger effects observed when the panels were visible from roads compared to when they were less visible. Besides, an experimental study conducted by Corrégé et al. (2018) employed a computer-based virtual home renovation decision-making task. In the experiment, a salient injunctive norm was manipulated, indicating that the government has set a goal of buildings' energy performance. Based on data extracted from Corrégé et al. (2018), participants in the salient injunctive norm condition were found to allocate a significantly higher budget to improve energy efficiency of the virtual home compared to those in the control condition.[3] Furthermore, social norms have been investigated through survey-based studies by examining perceived norms and their relationships with behavioural intentions. However, two survey studies found null effects of social norms. Lundheim et al. (2021) found no significant relationship between participants' beliefs about the prevalence of solar panel installations in specific regions, i.e., perceived descriptive norms, and their intention to install social panels. Similarly, Ma et al. (2022) found that households' willingness to undertake government-led energy-efficiency retrofit was not influenced by perceived support from neighbours and friends that implied an injunctive norm regarding social approval.[4]

Another relevant strand of literature is the influence of social factors on the diffusion of innovation. The Diffusion of Innovations Theory categorises consumers of an innovative technology as innovators, early adopters, early majority, late majority, and laggards according to the timing of adoption (Rogers, 2003). Early adopters generally hold more favourable opinions about innovative technologies and are important catalysts for the diffusion of these technologies (Wolske et al., 2020). On the other hand, the diffusion of innovative technologies can be impeded by negative social orientations towards innovative technologies and a lack of social contagion (MacVaugh & Schiavone, 2010), which suggest social disapproval and a low prevalence of innovation adoption. Rather than serving as direct motivations or barriers to adopting energy-efficient technologies, these social factors operate by providing substantive support and recognition of values. For example, early adopters can demonstrate the compatibility of an innovative technology, thus reducing the perceived uncertainties by later adopters (Wolske et al., 2020); later adopters may take action in order to be accepted socially and be awarded by their social community (MacVaugh & Schiavone, 2010).

In sum, previous studies have made significant progress in establishing psychological theories and conducting empirical research on the influence of social norms on daily energy conservation. However, there is still a lack of understanding regarding the role of social norms in complex home energy retrofit decisions. In addition, little research has been conducted to examine the potentially different pathways through which descriptive and injunctive social norms influence home energy retrofit choices. This study aims to fill these research gaps by investigating the relationship between perceived social norms and energy retrofit plans. Furthermore, we explore how perceived social norms are associated with perceived barriers and motivations that directly influence energy retrofit decisions. By addressing these issues, we aim to contribute to a better understanding of the role of social norms in shaping individual behaviours in the built environment and inform the design of behavioural policy instruments.

3. Methods

3.1. Dutch household survey

To gain comprehensive insights into homeowners' perspectives on home energy retrofit, a survey questionnaire was designed and distributed among Dutch homeowners in 2022. Participants were recruited by *Milieu Centraal*, an independent think tank specialising in the environment and energy sector, using their panel of Dutch homeowners. The survey questionnaire covered topics such as homeowners' knowledge and experience of house maintenance, their attitudes

[3] A one-tailed independent sample t-test was conducted based on the reported mean and standard deviation of the budget spent on energy renovation in different treatment groups, as well as the sample size, which was considered more meaningful than the Pearson's correlation test used in the original study.

[4] A summary of the most relevant reviewed literature is available in Section B, SI.

Table 1
Summary statistics of socio-demographics, dwelling characteristics, and energy retrofit plan (N = 556).

Variable	Mean	Std. Dev.	Min	Max
Female	0.48	0.50	0	1
Age				
18–29	0.07	0.26	0	1
30–49	0.28	0.45	0	1
50–69	0.47	0.50	0	1
70 and above	0.17	0.38	0	1
Household monthly net income				
2000 euros and below	0.21	0.41	0	1
2000–3000 euros	0.28	0.45	0	1
3000–4000 euros	0.26	0.44	0	1
4000–5000 euros	0.15	0.35	0	1
5000 euros and above	0.10	0.30	0	1
Education				
Below secondary	0.27	0.45	0	1
Secondary	0.35	0.48	0	1
Bachelor's degree	0.17	0.38	0	1
Master's degree/PhD degree	0.21	0.41	0	1
Household size	2.20	1.20	1	11
Expect to move in 3 years	0.16	0.37	0	1
Dwelling type				
Apartment	0.28	0.45	0	1
Terraced house	0.39	0.49	0	1
(Semi-)detached house	0.31	0.46	0	1
Other	0.01	0.10	0	1
Energy label				
High (A and above)	0.17	0.38	0	1
Medium (B/C/D)	0.29	0.45	0	1
Low (E/F/G)	0.10	0.30	0	1
Unknown	0.44	0.50	0	1
Habit	1.1	0.85	0	3
Plan to retrofit in 2 years	0.49	0.50	0	1
Number of planned retrofit measures	0.87	1.20	0	8

Note: (1) Household size is defined as the number of people of the household. (2) Habit is proxied by the number of small energy-saving measures that the household has previously taken.

and experiences regarding home energy retrofit, adoption of small energy-efficient measures, as well as socio-demographic information and dwelling characteristics. For the purpose of this study, we focused our analysis on a subset of survey questions from the latter three sections of the questionnaire. A full list of the survey questions can be found in Section A of the Supplementary Information (SI).

To avoid any potential confounding that stemmed from previous retrofitting experiences, this study specifically focusses on the retrofit intention of households that did not previously undertake any retrofit measures, i.e., inexperienced retrofitters. Two criteria were used to screen eligible responses. Respondents who satisfied both conditions were identified as inexperienced retrofitters and their responses were included in the analysis of this study. The screening criteria were as follows:

- Respondents who selected "I have not applied any sustainable measures". for the question "Have you applied sustainable measures in your home in the past 5 years".
- Respondents who denied the statement that "I have taken sustainable measures".

At the beginning of the survey questionnaire, information on socio-demographics and dwelling characteristics was collected. Specifically, we collected information on participants' gender, age group, net household monthly income group, education level, household size, as well as the type of dwelling and energy label assigned to their respective homes. Besides, participants were asked to indicate their plans for a relocation in the near future, as this could potentially influence their intention to retrofit their current homes. To facilitate the analysis, certain original choice groups were combined, based on which multiple dummy variables (except household size) were created. Table 1 provides an overview of these variables.

The main outcome variables are related to households' energy retrofit plans. To assess these plans, respondents were asked to indicate whether they planned to undertake an energy retrofit within the next two years and if so, which measures they planned to adopt. A list of measures was provided for participants to choose from, including roof insulation, floor insulation, cavity wall insulation, exterior wall insulation, replacement of glass for HR++ or triple glass, purchase of a (hybrid) heat pump, purchase of solar panels, purchase of solar water heater, and other measures.

To assess perceived social norms related to energy retrofit, two questions were included. As shown in Table 2, the perceived descriptive social norms were captured by the question "To what extent do you think people around you (such as friends, family or neighbours) are engaged in energy conservation and sustainable home renovation" with options ranging from "little or no concern" to "relate to it a lot". In terms of perceived injunctive social norms, participants were asked to indicate the extent to which they agreed with the statement "Most people in my area think it is good to invest in sustainable measures" on a 5-point scale ranging from "strongly disagree" to "strongly agree", with an additional option for "I don't know".

To help understand the direct driving factors of home energy retrofit decisions, we incorporated questions on motivations and barriers into the analyses. For motivations, participants were provided with a comprehensive list of 12 options from which they could select up to three. These motivations include increasing comfort, aesthetics, saving energy costs, pro-environmental concerns, increasing energy independence, combining with maintenance measures, investing in houses, acquiring subsidies, the desire to showcase their homes, recommendations from personal networks or professionals, and enjoying new techniques. A detailed description of these motivations can be found in Table 3. In addition, participants were asked to indicate their agreement with 13 statements regarding barriers on a 5-point scale from "strongly disagree" to "strongly agree", with an additional option for "I don't know". The barriers considered in this study include costs, insufficient grants, hassles in obtaining grants/support/consultants/information/installation/

Table 2
Summary statistics of perceived social norms.

Variable	Survey question	N	Share
Perceived descriptive social norms	To what extent do you think people around you (such as friends, family or neighbours) are engaged in energy conservation and sustainable home renovation?		
Low	I think the people around me have little or no concern for it.	86	15.47%
Medium	I think the people around me are a bit concerned for it.	374	67.27%
High	I think people around me relate to it a lot.	96	17.27%
Perceived injunctive social norms	Most people in my area think it is good to invest in sustainable measures.		
Negative	(Strongly) disagree.	42	7.55%
Neutral	Neither agree, nor disagree.	134	24.10%
Positive	(Strongly) agree.	299	53.78%
Unknown	I don't know	81	14.57%

Table 3
Summary statistics of motivations for home energy retrofit.

Variable	Survey question	N	Share
Motivation	What are the main reasons for you to implement the measure(s) below in the next two years? Choose up to 3.		
Comfort	It provides increased comfort: it gets warmer inside faster or better, stays cooler in summer and/or draughts less.	112	20.14%
Aesthetic	It makes my home look nicer.	4	0.72%
Energy cost	It reduces energy consumption and hence energy bills.	225	40.47%
Environment	It reduces energy consumption and hence CO_2 emissions, which is better for the environment.	135	24.28%
Increasing energy independence	It allows me to generate my own energy and be independent.	80	14.39%
Measures combination	It combines well with other (necessary) measures.	26	4.68%
Investment	I see it as a good investment, for example for the value of my home.	108	19.42%
Subsidy	I can get subsidy to implement this measure.	67	12.05%
Showcase	I can show it as an example to others, I can inspire people.	9	1.62%
Recommended network	It is recommended to me by friends/family/colleagues.	13	2.34%
Recommended professionals	It is recommended to me by the contractor/supplier.	1	0.18%
New technique	I enjoy applying new techniques.	11	1.98%

Table 4
Summary statistics of barriers for home energy retrofit.

Variable	Survey question	Mean	Share of N/A
Barrier	Please indicate the extent to which you agree with the statements below. [Strongly disagree = 1; disagree = 2; neither disagree nor agree = 3; agree = 4; strongly agree = 5; I don't know = N/A.]		
Cost	Sustainable measures are not expensive. [R]	3.90	7.01%
Grant	There are sufficient grants to fund them. [R]	3.42	25.18%
Find support	I have to put a lot of effort and time into finding support such as grant schemes.	3.69	18.53%
Find consultant	I have to put a lot of time and effort into finding the right consultant or contractor.	3.71	20.86%
Find information	I have to put a lot of time and effort into finding reliable information.	3.58	13.85%
Installation	I have to put a lot of time and effort into installing sustainable measures.	3.52	21.76%
Monitoring	I have to put a lot of time and effort into monitoring implementation.	3.34	24.28%
Own experience	I have positive experiences with previous renovations. [R]	3.01	35.61%
Observed experience	I know people around me have had negative experiences with previous renovations.	2.75	34.35%
Feasibility	With my property, taking sustainable measures is difficult (architectural reasons, monument, etc.).	2.80	14.57%
Uncertain benefit	I am confident about the benefits of sustainable measures such as saving energy and saving on energy bills. [R]	2.30	8.45%
Contractor quality	I have doubts about the quality of contractors.	3.09	15.11%

Note: [R] indicates reversely coded items.

monitoring, unpleasant personal or observed experiences, feasibility concerns, uncertainty regarding benefits, and quality concerns. The full list of the barrier statements is presented in Table 4.

Finally, we accounted for the energy efficiency habits of households as a control variable. To measure habits, we posed a question on the implementation of small energy-saving measures that can readily reduce energy consumption. In particular, participants were asked to indicate whether they had taken the following actions: (1) applying small energy-saving measures such as led lamps, radiator foil, and draught strips, (2) switching from gas cooking to an electric hob, and (3) replacing energy-intensive white goods (e.g., fridge, washing machine, dryer) with energy-efficient alternatives. The binary answers of these three items were aggregated to create the habit variable.

3.2. The sample

The Dutch household survey collected a total of 1738 valid responses. Given the focus of this study on households that had not previously implemented any retrofit measures, a sample of 556 Dutch homeowners without previous retrofit experiences was obtained based on the two screening questions outlined above.

As shown in Table 1, approximately 48% of the subjects were female; 7%, 28%, 47%, and 17% belonged to the 18–29 years old, 30–49 years old, 50–60 years old, and above 70 years old age groups, respectively. In terms of household monthly net income, 21%, 28%, 26%, 15%, and 10% of the subjects had an income below 2000 euros, between 2000 and 3000 euros, between 3000 and 4000 euros, between 4000 and 5000 euros, and above 5000 euros. Regarding education level, 27%, 35%, 17%, and 21% of the subjects had below secondary education, secondary education, bachelor's degree, and master's degree or above. The average household size was 2.2 people. Besides, 16% of the subjects expressed an intention to move within the next three years.

With respect to dwelling characteristics, as shown in Table 1, 28% of the respondents resided in an apartment (including ground floor apartment, upstairs apartment, maisonette, gallery, or flat), 39% lived in a terraced or corner house, 31% lived in a detached or semi-detached house. In addition, 17% of the respondents had homes with an A or A+ label, 29% had a medium home energy efficiency level with B/C/D labels, 10% lived in relatively less energy-efficient homes with E/F/G labels, and the remaining 44% were uncertain about their energy label. We controlled for these dwelling characteristics as they may lead to differences in the perceived necessity and feasibility of undertaking home energy retrofit measures.

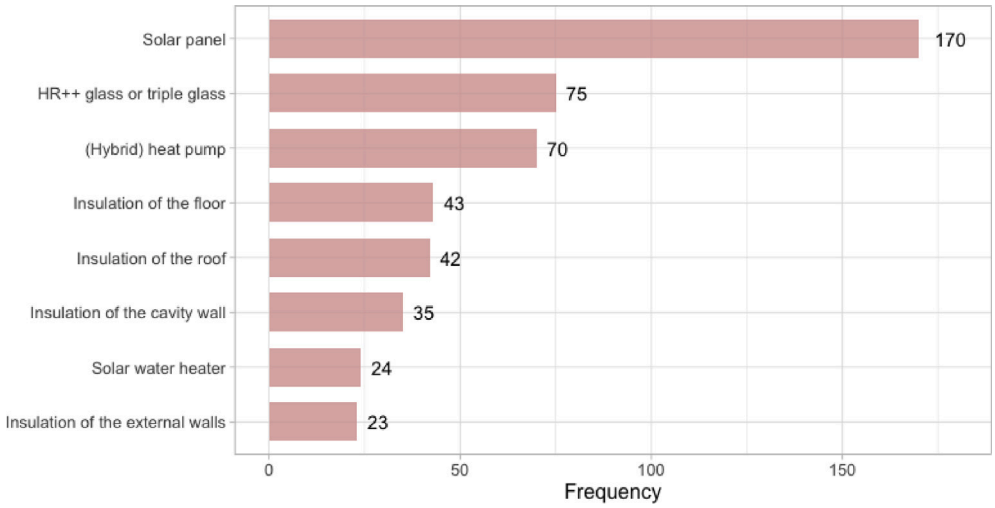

Fig. 1. Frequency of planned energy retrofit measures.

4. Descriptive results

4.1. Energy retrofit plans

As shown in Table 1, the number of planned retrofit measures ranges from zero to eight. On average, households within our sample indicated a plan to implement no more than one measure in the next two years ($M = 0.87$). In particular, slightly more than half (51.44%) of the surveyed households had no retrofit plans, 25.90% of the households planned to implement one measure, 13.13% planned two measures, 5.76% planned three measures, and 3.78% expressed intentions to undertake four or more measures.

Fig. 1 presents the frequency distribution of retrofit measures selected by respondents. Among the eight measures, installing solar panels was the most frequently planned measure in the near future, followed by glass insulation and heat pumps. However, solar water heaters as well as the insulation of floors, roofs, cavity walls, and external walls, were mentioned less frequently.[5]

4.2. Perceived social norms

As shown in Table 2, within our sample, a majority of the respondents (67.27%) perceived the descriptive social norms to be low, while 15.47% and 17.27% of the respondents reported medium and high perceived descriptive social norms, respectively. Concerning the injunctive social norms about home energy retrofit, slightly more than half of the respondents (53.78%) held a positive perception. Negative and neutral perceptions of injunctive social norms were reported by 7.55% and 24.10% of the respondents, respectively. Furthermore, 14.57% of the respondents did not express any perceptions about injunctive social norms.

To explore the heterogeneity of perceived social norms, we investigated the correlation between perceived social norms and demographic factors through two Ordinary Least Squares (OLS) models. Results are presented in Table 5. Specifically, female respondents exhibited a higher correlation with both higher perceived description norms and more positive perceived injunctive social norms compared to male respondents. Age was negatively correlated with both types of social norms. Besides, income was positively correlated with perceived injunctive social norms. For perceived descriptive social norms, the highest income group exhibited a higher perception compared to the lowest income group, while the difference was not significant between other income groups and the lowest group. Lastly, homeowners with a higher education level of Bachelor's and above exhibited more positive perceived injunctive social norms.

4.3. Motivations and barriers for energy retrofit

As shown in Table 3, the primary motivations for retrofit included saving energy costs, pro-environmental concerns, increasing comfort, investing in houses, increasing energy independence, and acquiring subsidies. These motivations generally revolved around the goal of using energy services in a safe, cost-efficient, and energy-efficient manner. However, motivations that are not directly related to the quality and efficiency of energy services were less frequently mentioned, such as aesthetics, convenience of combining measures, the desire to showcase their homes, recommendations from others, and enjoying new techniques.

The perceived barriers to retrofit are summarised in Table 4. On average, respondents identified financial costs as the primary barrier to implementing retrofit measures. Related to this, the availability of grants was another important financial obstacle. Other identified barriers included the hassles, such as the time and effort involved in finding support, consultants or contractors, and information, as well as the concerns about the quality of contractors. In addition, on average, homeowners did not consider the uncertainty in energy-saving benefits, the feasibility of measures for their homes, or observed negative experiences as barriers.

Furthermore, a notable proportion of the respondents reported "I don't know" for the statements of perceived barriers, indicating a lack of experience or expectations regarding potential difficulties. Specifically, more than one-third of the respondents had no personal or observed experiences of implementing retrofit measures. Approximately 20% of the respondents could not assess the difficulties in acquiring grants, finding support, finding consultants or contractors, installing, monitoring implementation, or evaluating contractor quality. Besides, less than 10% of the respondents did not express an opinion on the perceived costliness of the retrofit measures and the certainty of energy-saving outcomes.

5. Results

5.1. Energy retrofit plans and perceived social norms

To investigate the relationship between energy retrofit plans and social norms, we separately regress the binary decision to undertake

[5] Information on the frequency of planned energy retrofit measures per dwelling type is available in Section C, SI.

Table 5
OLS estimates of the correlation between demographics and social norms.

Variable	DV: Perceived descriptive social norms			DV: Perceived injunctive social norms		
	Coef.	Std. Err.	p	Coef.	Std. Err.	p
(Intercept)	2.136***	(0.114)	0.000	3.450***	(0.189)	0.000
Female	0.084*	(0.050)	0.092	0.220***	(0.075)	0.003
Age: 30–49	−0.176*	(0.092)	0.056	−0.199	(0.140)	0.156
Age: 50–69	−0.209**	(0.091)	0.022	−0.366**	(0.142)	0.010
Age: 70 and above	−0.273**	(0.108)	0.012	−0.509***	(0.170)	0.003
Income: 2000–3000 euros	0.057	(0.079)	0.472	0.187	(0.118)	0.113
Income: 3000–4000 euros	0.047	(0.081)	0.563	0.283**	(0.121)	0.020
Income: 4000–5000 euros	0.083	(0.086)	0.335	0.260*	(0.137)	0.058
Income: 5000 euros and above	0.175*	(0.098)	0.074	0.306*	(0.166)	0.065
Edu: secondary	−0.075	(0.068)	0.267	0.098	(0.108)	0.367
Edu: bachelor's	0.046	(0.079)	0.563	0.321***	(0.117)	0.006
Edu: master's/PhD	−0.007	(0.072)	0.924	0.353***	(0.116)	0.002
Adjusted R-squared		0.013			0.105	
Obs.		556			475	

Note: (1) Robust standard errors are in parentheses. (2) 81 observations indicating "I don't know" for perceived injunctive social norms were omitted.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

energy retrofitting and the decision on the number of retrofit measures on dummy variables representing different degrees of perceived descriptive social norms and perceived injunctive social norms related to home energy retrofit. In other words, the former analysis focused on the probability of planning to undertake retrofit, while the latter examined the depth of the planned energy retrofit.

To understand the probability of planning to undertake retrofit, a set of probit regressions was conducted (see Section D, SI). Below, we present the full model specification with all independent variables included and the corresponding results. The binary dependent variable Y takes 1 if at least one home energy retrofit measure was planned in the next two years and 0 if no retrofit measures were planned. The probability of $Y = 1$ is determined by a vector of regressors $\boldsymbol{X}$. In probit models, the link function Φ is the cumulative distribution function.

$$P(Y = 1|\boldsymbol{X}) = \Phi(\boldsymbol{X}\boldsymbol{\beta}) \tag{1}$$

For individual observation i, the full probit model specified as a latent variable model is as follows:

$$\begin{aligned} y_i^* &= \beta_0 + \boldsymbol{NORMS}_i\boldsymbol{\beta}_1 + \beta_2 HABBIT_i \\ &\quad + \beta_3 MOVE_i + \boldsymbol{CONTROL}_i\boldsymbol{\beta}_4 + \varepsilon_i \\ y_i &= \begin{cases} 1 & if\ y_i^* > 0 \\ 0 & otherwise \end{cases} \end{aligned} \tag{2}$$

where y_i^* is the latent variable linked with the binary output variable y_i; $\boldsymbol{NORMS}_i$ denotes a vector of variables of different levels of perceived descriptive and injunctive social norms (the medium-level perceive descriptive norms and the non-positive perceived injunctive norms are reference groups, respectively); $HABBIT_i$ is the variable indicating household's energy efficiency habits, proxied by the number of previously implemented small energy-saving measures; $MOVE_i$ denotes the dummy variable of planning to undertake relocate in three years; $\boldsymbol{CONTROL}_i$ is a vector of control variables, including dwelling and socio-demographic characteristics; $\boldsymbol{\beta_1}, \beta_2, \beta_3, \boldsymbol{\beta_4}$ are coefficients or the transpose of a vector of coefficients; ε_i is a random error term.

The estimated coefficients and average partial effects are presented in Table 6. The results indicate that the perceived descriptive social norms at different levels do not appear to be significantly related to the probability of planning to undertake retrofit ($b_{low} = -0.130$, $p = 0.454$; $b_{high} = 0.259$, $p = 0.105$). However, the coefficient of positive perceived injunctive social norms is positive and statistically significant ($b_{positive} = 0.336$, $p = 0.021$). This suggests that compared to individuals who perceive injunctive social norms to be negative or neutral, holding a positive perception is significantly associated with a 11.8 percentage point higher likelihood of planning retrofit measures.

In addition, several dwelling and household characteristics exhibit positive associations with the likelihood of planning retrofit measures, including energy efficiency habits, dwelling types with relatively independent structures, less efficient energy labels, and relatively high income levels. Specifically, implementing an additional small energy-saving measure is found to increase the average likelihood of planning retrofit measures by 7.1 percentage points. Compared to households residing in apartments, those living in terraced houses and (semi-)detached houses show a higher likelihood of planning retrofit measures of 13.8 and 24.3 percentage points, respectively. Moreover, households with energy labels of B/C/D have a 14.1 percentage points higher likelihood of planning retrofit measures compared to those residing in A or A+ houses. Note that the coefficient and average partial effect for energy labels of E/F/G classes are positive but statistically insignificant. Additionally, in comparison to households with incomes below 2000 euros, households with monthly net incomes of 3000–4000 euros and 4000–5000 euros exhibit a 12.0 and 19.5 percentage points higher likelihood of planning retrofit measures, respectively. Households with a plan to move within the next three years have an average 12.7 percentage points lower likelihood of planning retrofit measures, as opposed to households without a move plan or those planning to move further ahead. Lastly, female respondents demonstrate a lower likelihood of making retrofit plans, although the results are marginally significant at the 10% level.

Next, we shift our focus to assessing the relationship between the depth of planned energy retrofit and perceived social norms, as well as other dwelling and household attributes. The depth indicator is proxied by the number of planned energy retrofit measures, which provides a more precise reflection of retrofitting decisions. The dependent variable, representing the number of planned energy retrofit measures, is count data, ranging between 0 and 8. Furthermore, the dependent variable is overdispersed (dispersion index = 1.240, $p = 0.023$), which rejects the Poisson distribution of the dependent variable assumed by Poisson regressions. Given these characteristics of the data, the negative binomial regression is suitable for our analysis. Therefore, we estimate a set of negative binomial regressions (see Section D, SI). In the following, we present and interpret the full model, which includes all independent variables. The probability of planning to take z_i number

Table 6
Determinants of the probability of planning to retrofit (probit model).

Variable	DV: Plan to retrofit = 1					
	Coef.	Std. Err.	p	Ave. Par. Eff.	Std. Err.	p
(Intercept)	−1.097***	(0.363)	0.003			
Perceived descriptive social norms: low	−0.130	(0.174)	0.454	−0.045	(0.060)	0.455
Perceived descriptive social norms: high	0.259	(0.160)	0.105	0.089	(0.055)	0.103
Perceived injunctive social norms: positive	0.336**	(0.145)	0.021	0.118**	(0.052)	0.022
Perceived injunctive social norms: unknown	−0.075	(0.184)	0.683	−0.026	(0.064)	0.683
Habit	0.206***	(0.070)	0.003	0.071***	(0.023)	0.003
Expect to move in 3 years	−0.374**	(0.159)	0.019	−0.127**	(0.052)	0.016
Dwelling: terraced house	0.408***	(0.147)	0.005	0.138***	(0.048)	0.004
Dwelling: (semi-)detached house	0.707***	(0.159)	0.000	0.243***	(0.051)	0.000
Dwelling: other	0.615	(0.555)	0.267	0.204	(0.169)	0.228
Energy label: B/C/D	0.409**	(0.178)	0.022	0.141**	(0.060)	0.019
Energy label: E/F/G	0.349	(0.227)	0.125	0.119	(0.076)	0.116
Energy label: unknown	0.216	(0.168)	0.198	0.073	(0.056)	0.190
Female	−0.192*	(0.117)	0.100	−0.066*	(0.040)	0.099
Age: 30–49	−0.041	(0.242)	0.865	−0.014	(0.082)	0.864
Age: 50–69	−0.302	(0.243)	0.214	−0.103	(0.081)	0.206
Age: 70 and above	−0.438	(0.277)	0.113	−0.150	(0.092)	0.104
Income: 2000–3000 euros	0.255	(0.169)	0.132	0.087	(0.057)	0.125
Income: 3000–4000 euros	0.354**	(0.177)	0.046	0.120**	(0.059)	0.040
Income: 4000–5000 euros	0.567***	(0.218)	0.009	0.195***	(0.072)	0.007
Income: 5000 euros and above	0.162	(0.249)	0.517	0.056	(0.086)	0.517
Edu: secondary	0.055	(0.153)	0.720	0.019	(0.053)	0.720
Edu: bachelor's	0.111	(0.189)	0.559	0.038	(0.065)	0.559
Edu: master's/PhD	−0.025	(0.202)	0.900	−0.009	(0.069)	0.900
Household size	0.040	(0.052)	0.439	0.014	(0.018)	0.438
Log-likelihood				−334.749		
Observations				556		

Note: For perceived descriptive social norms, "medium perception" is the reference group. For perceived injunctive social norms, "non-positive perception" (a negative or neutral perception) is the reference group.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

of retrofit measures by homeowner i is given by:

$$P(Z = z_i|\mu_i, \alpha) = \frac{\Gamma(z_i + \alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(z_i + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i}\right)^{\alpha^{-1}} \left(\frac{\mu_i}{\alpha^{-1} + \mu_i}\right)^{z_i} \quad (3)$$

where α is the overdispersion parameter; and μ_i is a function of independent variables, which have the same definition as in Eq. (2); $\boldsymbol{\gamma_1}, \gamma_2, \gamma_3, \boldsymbol{\gamma_4}$ are coefficients or transpose of a vector of coefficients; ν_i is an error term.

$$\mu_i = exp(\gamma_0 + \boldsymbol{NORMS}_i\boldsymbol{\gamma}_1 + \gamma_2 HABBIT_i + \gamma_3 MOVE_i + \boldsymbol{CONTROL}_i\boldsymbol{\gamma}_4 + \nu_i) \quad (4)$$

The estimated coefficients and average partial effects are shown in Table 7. Different from the results on the probability of planning to undertake retrofit, the number of planned retrofit measures is positive and significantly predicted by high perceived descriptive social norms (b_{high} = 0.408, p = 0.003). The average partial effects indicate that compared to individuals perceiving a medium level of descriptive social norms, people who perceive the norms to be high are likely to plan an average of 0.4 more retrofit measures. Besides, similar to the finding of the probit model, perceiving positive injunctive social norms is positively associated with the number of planned measures ($b_{positive}$ = 0.302, p = 0.036).

Furthermore, a majority of estimates of dwelling and socio-demographic characteristics are consistent with the results of the probit model. Despite the similarities, the negative binomial model further identifies the significant role of age that the older age groups are associated with a lower number of planned retrofit measures (b_{50-69} = −0.394, p = 0.053; $b_{70and above}$ = −0.707, p = 0.006).

5.2. Decision barriers, motivations, and perceived social norms

In addition to examining the relationship between energy retrofit plans and social norms, we further investigate whether perceived social norms are related to the motivations and barriers that directly drive retrofitting decisions. This analysis aims to provide insights into the channels through which social norms may influence home energy retrofit decisions.

First, each motivation factor was regressed on social norm variables while controlling for dwelling and socio-demographic characteristics. Estimates were derived using OLS models with robust standard errors. Detailed regression results can be found in Section E, SI. The main results are summarised in Fig. 2, which presents the estimated coefficients and the 90% confidence intervals of social norm variables. The results indicate that compared to homeowners perceiving medium levels of descriptive social norms, those with a high perception exhibit a higher likelihood of identifying motivations related to making investments and inspiring others. Additionally, a positive perception of injunctive social norms is significantly associated with a broader range of motivations, including increasing home comfort, reducing energy costs, benefiting the environment, increasing energy independence, and making investments.

To examine the relationship between perceived social norms and barriers to retrofit, we conducted regression analyses for each perceived barrier while controlling for dwelling and socio-demographic characteristics. Similarly, OLS models with robust standard errors were employed, and the full results are available in Section E, SI. The main results are shown in Fig. 3, which displays the estimated coefficients and the 90% confidence intervals of social norm variables. Results

Table 7
Determinants of the number of planned retrofit measures (negative binomial model).

Variable	DV: Number of planned measures					
	Coef.	Std. Err.	p	Ave. Par. Eff.	Std. Err.	p
(Intercept)	−1.337***	(0.339)	0.000			
Perceived descriptive social norms: low	0.018	(0.183)	0.920	0.016	(0.161)	0.920
Perceived descriptive social norms: high	0.408***	(0.136)	0.003	0.402***	(0.153)	0.009
Perceived injunctive social norms: positive	0.302**	(0.144)	0.036	0.253**	(0.118)	0.031
Perceived injunctive social norms: unknown	0.132	(0.193)	0.492	0.121	(0.186)	0.515
Habit	0.184***	(0.066)	0.005	0.160***	(0.058)	0.006
Expect to move in 3 years	−0.396**	(0.158)	0.012	−0.302***	(0.106)	0.004
Dwelling: terraced house	0.530***	(0.151)	0.000	0.507***	(0.164)	0.002
Dwelling: (semi-)detached house	0.768***	(0.159)	0.000	0.781***	(0.198)	0.000
Dwelling: other	0.819	(0.536)	0.126	1.095	(1.046)	0.295
Energy label: B/C/D	0.454**	(0.177)	0.010	0.437**	(0.192)	0.023
Energy label: E/F/G	0.723***	(0.211)	0.001	0.855**	(0.336)	0.011
Energy label: unknown	0.305*	(0.173)	0.077	0.278*	(0.167)	0.095
Female	−0.255**	(0.110)	0.021	−0.219**	(0.095)	0.021
Age: 30–49	−0.183	(0.201)	0.361	−0.156	(0.168)	0.353
Age: 50–69	−0.394*	(0.204)	0.053	−0.344*	(0.183)	0.060
Age: 70 and above	−0.707***	(0.256)	0.006	−0.485***	(0.142)	0.001
Income: 2000–3000 euros	0.347**	(0.177)	0.050	0.330*	(0.186)	0.076
Income: 3000–4000 euros	0.287	(0.186)	0.121	0.271	(0.191)	0.156
Income: 4000–5000 euros	0.430**	(0.208)	0.039	0.435*	(0.245)	0.076
Income: 5000 euros and above	0.370	(0.229)	0.106	0.372	(0.266)	0.162
Edu: secondary	0.092	(0.156)	0.552	0.082	(0.139)	0.558
Edu: bachelor's	0.124	(0.184)	0.499	0.112	(0.173)	0.516
Edu: master's/PhD	0.118	(0.187)	0.530	0.105	(0.173)	0.542
Household size	−0.014	(0.047)	0.763	−0.012	(0.041)	0.763
Log-likelihood				−661.490		
Alpha				0.296		
Observations				556		

Note: For perceived descriptive social norms, "medium perception" is the reference group. For perceived injunctive social norms, "non-positive perception" (a negative or neutral perception) is the reference group.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

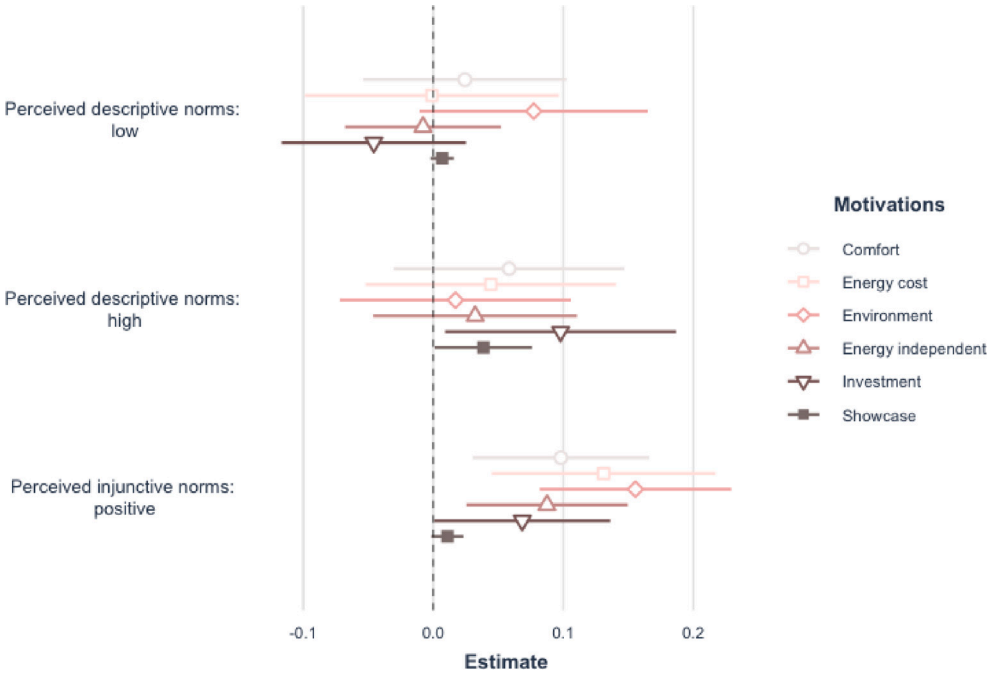

Fig. 2. OLS estimates for motivations for home energy retrofit.

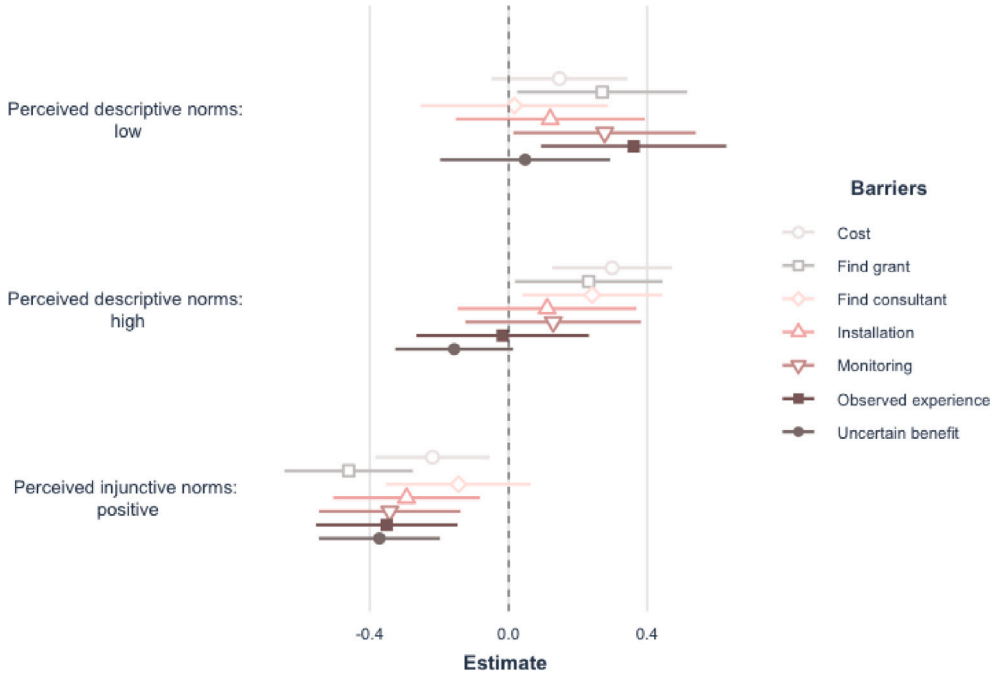

Fig. 3. OLS estimates for barriers for home energy retrofit.

indicate that compared to perceiving a medium level of descriptive social norms, individuals with a low perception tend to report stronger perceived barriers concerning the hassles during installation and monitoring. Interestingly, those perceiving high descriptive social norms tend to express greater concerns related to costs, as well as the hassles in finding grants and consultants or contractors. However, a positive perception of injunctive social norms is generally associated with fewer perceived barriers to retrofitting. Specifically, individuals with a positive perception of injunctive social norms, versus neutral or negative, are less concerned with barriers such as costs, negative experiences of others, uncertain benefits, as well as the hassles in finding grants, installation, and monitoring.

6. Discussion

In summary, our findings reveal different patterns in the relationship between home energy retrofit plans and different types of perceived social norms. The binary decision on undertaking retrofit measures in the future is primarily related to perceived injunctive social norms, whereas the number of planned retrofit measures is associated with both perceived descriptive and perceived injunctive social norms. Additionally, perceptions of these two types of social norms are associated with a range of motivations and barriers to retrofit, with varying strengths and even opposite directions of relationship. These empirical findings shed light on potentially different pathways through which social norms are linked with home energy retrofit decisions.

In particular, positive perceived injunctive social norms, which refer to beliefs about positive attitude towards energy retrofit among people around oneself, are overall conducive to forming an intention to retrofit. With positive perceived injunctive social norms, homeowners' self-evaluated motivations for retrofitting are generally stronger, while the perceived barriers are generally weaker, compared to those perceiving injunctive social norms to be neutral or negative. These relatively strong motivations and weak perceived barriers can ultimately contribute to a positive relationship with energy retrofit plans. One possible explanation for the prominent role of perceived injunctive social norms is the high level of internalisation of injunctive norms. According to the taxonomy proposed by Thøgersen (2006), various types of social norm are distinguished based on their degree of internalisation, that is, the extent to which complying with the norm is motivated by internal values (Schwartz, 1977). The more internalised norms are believed to be more predictive of the corresponding behaviour. In this framework, descriptive social norms lie at the external end of the spectrum, and towards the internal side, injunctive social norms are further decomposed into perceived injunctive social norms, introjected personal norms, and integrated personal norms.[6] Perceived injunctive social norms are considered to be more internalised than descriptive social norms, which can be further superficially internalised as introjected personal norms. Following this line of reasoning, positive perceived injunctive social norms can reflect and shape the more deeply internalised personal norms, thus consistently aligning with the assessment of the direct driving factors (motivations and barriers) of and intentions to retrofitting. Another possible explanation for the prominent role of perceived injunctive social norms is related to the type of social influence exerted by perceived injunctive social norms. As discussed in Section 2, injunctive social norms are rooted in the desire for social approval, which corresponds to the normative social influence pathway. Therefore, perceived injunctive social norms may exert a normative social influence, leading not only to behavioural intentions but also to a positive assessment of the direct driving factors of the behaviour without much conscious elaboration.

Unlike injunctive norms, high perceived descriptive social norms, which refer to beliefs about high engagement in energy retrofit among people around oneself, are associated with the number of planned retrofit measures, but not the binary decision of planning to undertake retrofit. This finding is in accordance with the motivational forces of descriptive social norms, that is, the desire for accurate/efficient decisions (Jacobson et al., 2011). In addition, high perceived descriptive social norms are even positively associated with some perceived barriers and are only related to specific motivations. This finding suggests

[6] The latter three norms were labelled as subjective social norms, introjected norms, and integrated norms by Thøgersen (2006). We slightly modify the names for consistency and ease of understanding.

that perceived descriptive social norms can affect retrofit decisions through an informational social influence process (Göckeritz et al., 2010), in which influence on behaviour occurs by gathering information from others. In the context of this study, where social norms were formed endogenously, it is possible that both the formation of descriptive normative beliefs and the process of informational social influence were enabled by interpersonal communication and persuasion (Wolske et al., 2020). As a result, interpersonal communication and persuasion may increase perceived descriptive social norms; meanwhile, the acquisition of better information through communication can enable deliberation and lead to a more conscious evaluation of the benefits and barriers of home energy retrofit. It is worth noting that descriptive social norms can also induce the desire for social approval, thus having normative social influence (Göckeritz et al., 2010). However, this study cannot empirically disentangle the informational and normative social influences of descriptive social norms.

Compared with simple actions such as curtailing daily energy consumption, home energy retrofit such as installing solar panels and insulation is more difficult, involving higher upfront costs and conscious deliberation. As noted in previous studies, the curtailment of daily energy consumption can be readily influenced by exogenously provided social norms (e.g., Allcott, 2011; Allcott & Rogers, 2014; Andor et al., 2020; Bonan et al., 2020, 2021; Nolan et al., 2008). In these field experiments, descriptive social norms are found to influence energy conservation behaviour through a non-conscious, automatic route, and injunctive social norms can boost this influence (Bonan et al., 2020; Göckeritz et al., 2010). However, our study suggests that different influencing pathways may apply to home energy retrofit decisions. Specifically, perceived injunctive social norms appear to be relatively internalised and exert a normative social influence. A comprehensive pursuit of social approval is central to injunctive social norms. On the other hand, perceived descriptive social norms are found to be more closely related to careful consideration of the home energy retrofit. Unlike relatively simple conservation behaviour, when making energy retrofit decisions, descriptive social norms seem to facilitate the desire to make accurate and efficient decisions and are related to informational social influence.

We acknowledge several limitations of this study and highlight some implications for future research. Firstly, the social norms were self-reported, and the econometric analysis in this study is limited to identifying correlational relationships rather than establishing causality. Future research can investigate the effectiveness of leveraging social norms as a behavioural policy intervention through (quasi-)experiments. Secondly, the formation of self-reported perceived social norms was not traceable in this study. Building on the empirical results and theories discussed earlier, we propose different potential pathways for descriptive and injunctive social norms to form and exert influences such as through interpersonal communication and persuasion. However, a formal examination of the speculation is beyond the scope of this study. Furthermore, it is reasonable to assume that perceived descriptive and injunctive social norms will change as new retrofit measures develop and diffuse. According to the Diffusion of Innovations Theory, diffusion occurs through multiple stages (Rogers, 2003). Over time, an innovation will gradually be adopted by an increasing number of people, from a small group of "innovators" at the initial stage to the majority at later stages. Therefore, it is interesting for future research to investigate the formation of social norms at different diffusion stages and the potentially dynamic roles of social norms as technology develops. Thirdly, there is a need to explore the heterogeneity of the role of social norms. In particular, home energy retrofit is a multi-stage, complex decision, involving steps such as getting interested in retrofit, gaining knowledge, forming an opinion, making a decision, implementing, and experiencing (Klöckner & Nayum, 2016). While this study primarily focusses on the "making a decision" stage, it is important to recognise that social norms may play different roles at different stages of retrofitting. For instance, descriptive social norms might impact the initial stage of "getting interested" by triggering curiosity and raising awareness through observing others' retrofitting behaviours (Wolske et al., 2020). Furthermore, given the differences in the necessity and feasibility of undertaking energy retrofit in different types of dwelling and for different socio-demographic groups, the potentially heterogeneous role of social norms related to socio-demographic status is also worth investigating.

7. Conclusion and policy implications

The aim of this study was to investigate the role of perceived social norms in energy retrofit plans. By analysing self-reported data from a sample of Dutch homeowners without previous retrofit experiences, we found that perceived injunctive social norms are aligned with the binary decision of planning retrofit measures, the decision on the number of planned retrofit measures, and various perceived motivations and barriers for home energy retrofit. This suggests that perceived injunctive social norms could exert a normative social influence, which is enabled by the strong pursuit for social approval by homeowners. However, perceived descriptive social norms are only associated with the more precise measure of retrofit plans, i.e., the number of planned retrofit measures, and are even positively correlated with some perceived barriers to retrofit. This finding suggests that perceived descriptive social norms can be associated with an informational social influence with careful deliberation, whereby individuals gather information from others to make more realistic and efficient decision on retrofitting.

We conclude by highlighting a few implications for policy-making and local practises to promote home energy retrofit. In general, policymakers and neighbourhood initiatives should more consciously differentiate between descriptive and injunctive social norms. In particular, communicating home energy retrofit as a socially desired behaviour, which indicates positive injunctive social norms, can be powerful in shaping positive attitudes and behavioural intentions of homeowners. This can be achieved through various approaches, such as public awareness campaigns, testimonials from satisfied retrofitters, and showcasing successful retrofit projects in the community. Furthermore, during the decision-making stage of energy retrofitting, descriptive social norms may serve as a source of reliable information to guide the choice of effective retrofit measures and encourage more measures to be undertaken. Finally, although the formation of perceived social norms is beyond the scope of this study, it is likely that the norm formation process is associated with interpersonal communication and persuasion. Therefore, creating a social environment to allow homeowners to interact and communicate with each other about home energy retrofit can be beneficial. Local initiatives, such as Solar Community Organisations, may play an active role in facilitating such communication channels and providing platforms for information sharing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.scs.2023.104954.

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