Activating Energy Communities for Systemic Change

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Abstract. The speed of energy transition in the Netherlands is low, in contrast to its 2050 climate change target of net-zero emissions. The transition requires 7.5 million households with natural gas connections, to move to renewable energy sources. The main challenge is not technical, many viable options are already available, but social: people will need to be supported to decide and act. In this paper, we identify interventions that could activate change within energy communities, through 19 interviews conducted in March 2021 in Austerlitz, Zeist municipality, The Netherlands. Interview questions were guided by the Capability, Opportunity, Motivation, and Behavioural (COM-B) change model. The model explains factors that affect people's behaviour. Results indicate that renovation and energy transition are viewed as two separate processes. Austerlitz homeowners are waiting for the government to lead the energy transition process, while they continue to renovate their homes to improve comfort, aesthetics, safety, and convenience. Also, current interventions towards activating households are piecemeal and more focused on creating external opportunities (such as financial support), and barely address the psychological capabilities and motivation factors (belief, attitude, social norm, and perceived behavioural control). To boost psychological capabilities and motivation, we recommend interventions that enhance homeowners' belief that the energy transition is part of their long-term home renovation plans, for their own benefit, to motivate them to drive the energy transition process. Interventions may include 'show' or 'display' houses where energy transition was combined with renovations and highlighting inspirational energy transition stories on the municipality website.

1 Introduction: Energy transition, a social challenge

On June 28th, 2019, the Netherlands agreed to a net-zero emissions by 2050 (Ministry van Economische Zaken en Klimaat, 2019). The scale of financial resources required to enforce gas discontinuation top-down, wherein individuals play essentially no decisive role, are indeed not available. With more than 7.5 million gas connections for Dutch households (Ebrahimigharehbaghi et al., 2019), reaching the net-zero emissions goal, is an immense challenge. Several studies indicate that the energy transition rate of The Netherlands is far too low to achieve the ambitious 2050 climate change target (Steenbekkers and Scholte, 2019, Ebrahimigharehbaghi et al., 2019, Broers et al., 2019, Filippidou et al., 2017). By and large, the Dutch energy transition approach has so far been technocratic, with an emphasis on exploring alternatives to natural gas heating systems e.g., all-electric, heat pumps, residual heat, geothermal systems (Raven and Verbong, 2007, Klaassen and Patel, 2013).

The great, yet often neglected challenge lies in activating households to adopt these already available technologies, not as a one-off event, but as part of their everyday life (Steg et al., 2021, Nash et al., 2019). Many viable options are available, but people will need to be activated to decide and act (Steenbekkers and Scholte, 2019). Studies reveal increasing awareness amongst citizens about the need for and value of sustainable lifestyles, yet it is not reflected in their behaviours and consumption patterns (Frederiks et al., 2015). This widens the gap between residents' intention to become sustainable and the corresponding action, the so-called intention-action gap or green gap (Thøgersen and Schrader, 2012, Vermeir and Verbeke, 2006). At the micro level, for a given household, the most viable alternative and sustainable energy source depends largely on contextual variables and is in any case associated with some investment (Steenbekkers and Scholte, 2019). For a household to substitute natural gas for an alternative sustainable energy source, insulation, window glazing and ventilation need to be upgraded (Broers et al., 2019). Even to adopt an alternative source of energy with the fewest required household-level adjustments (e.g., high temperature residual heat), associated costs are high and necessary infrastructural changes are substantial (Broers et al., 2019). The switch from natural gas to an alternative energy source, therefore, poses obstacles for households: investment and inconvenience in the short-term, and uncertainty in financial savings for the long-term (Liebe et al., 2011, Ligterink et al., 2019, Steenbekkers and Scholte, 2019, Jansma et al., 2020).

This paper seeks to increase the understanding of (un)sustainable energy behaviour and formulate interventions for municipalities to activate households. We specifically selected households rather than other energy users because "on the global level, 72% of greenhouse gas emissions are related to household consumption" (Hertwich and Peters, 2009). Thus, understanding household behaviour and how sustainable energy transition can be mobilised, at that level, is a critical component of climate policy (Dubois et al., 2019).

We held 19 semi- structured kitchen interviews, guided by the Capability, Opportunity, Motivation and Behavioural (COM-B) change model (Michie et al., 2015). The research objective is to understand different factors that may lead to either piecemeal, short-lived interventions or systemic interventions that spill over from one action to the next and the multiplier effect catalyses the much-needed change. The paper seeks to answer two research questions. First, what source of energy transition behaviour (capability, opportunity, and motivation) could activate systemic behavioural change at the household level? Second, what behavioural change interventions best address the identified system of behaviours? Findings bring to fore the value and limitations of the COM-B model in addressing systemic problems, where actions of millions of residents need to be sustained over long periods. We conclude that interventions should enhance homeowners' belief that energy transition is an intrinsic part of their long-term home renovation plans, to motivate them to drive the energy transition process. Moreover, the transition can be fast-tracked when households are financially enabled, and skills enhanced. The suggested approach will enhance homeowners' long-term engagement in energy transition, as main drivers of change.

The subsequent section reviews literature on behaviour change, introduces the behaviour change wheel and explains how the COM-B behaviour change model was operationalised in the research. In section 3, we contextualise the Austerlitz case study, and explain the methods, participants, and measures. Section 4 summarises the key findings. Finally, in section 5, we use the findings to identify which factors contribute to (un)sustainable behavioural spillover at the household level and formulate directions for interventions.

2 The COM-B Model of Behaviour and Intervention Functions

2.1 Behavioural change theories

Most behavioural change theories use the model of reasoned action to explain human action (Sahu et al., 2020, Nash et al., 2019). The Reasoned action model posits that energy consumers consider multiple options before making rational choices or decisions (Fishbein and Ajzen, 1977). However, when a decision is complex, uncertain, and involves large investments, it only makes sense for someone to act if several others have already acted and experienced positive results (Cialdini and Goldstein, 2004). Ajzen (1991) theory of Planned Behaviour (TPB) improves on the TRA by introducing perceived behavioural control (perceived ability to perform the behaviour) as a determinant of human action. According to TPB, if residents find the process too complex, most prefer to indefinitely defer energy transition decisions. Bem (1972)'s theory of self-perception further explains the present inaction. If people believe that natural gas is unsustainable and they need to transition to renewable energy sources but there is too much ambiguity, uncertainty and it is complex to even start the process, then they can either make the decision to immediately transition or adjust their belief system to justify inaction. In such circumstances, most people prefer not to act, leading to the present impasse where everyone is waiting for others to adopt sustainable energy sources, and consequently, nothing happens.

Reasoned action theories may not adequately predict human behaviour when applied in new contexts like energy transition, where information is lacking, conflicting or contested (Gilal et al., 2019, Hagger et al., 2002, Nash et al., 2017). Moreover, they fail to provide a formula for "wider lifestyle shifts" (Nash et al., 2017), at the household level. A person may make reasoned judgment on one behaviour (e.g., buy energy saving gadgets or install solar panels), but if they are not motivated to transition to renewable energy sources, they might not take up subsequent sets of behaviour to complete the entire process. Thus, to address these two main gaps in behavioural change theories, we decided to look closer into motivation, as a key component of behaviour change.

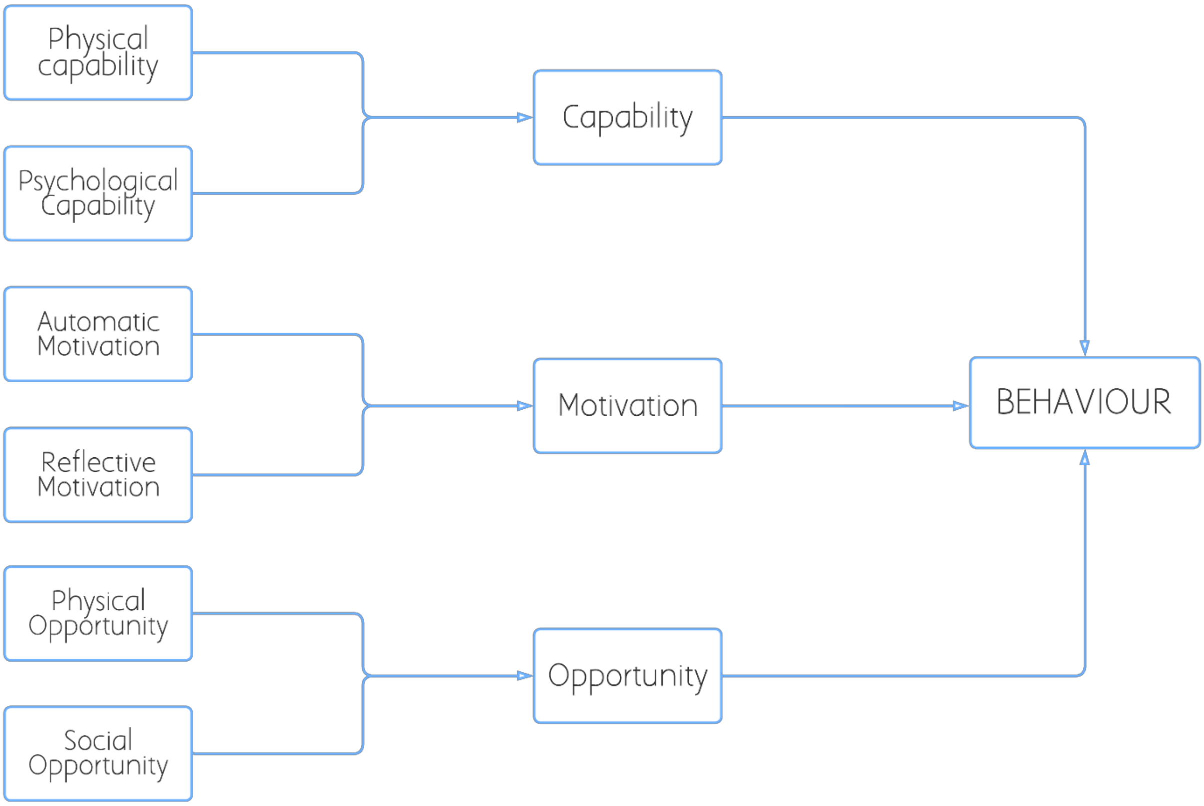
2.2 PRIME Theory and the COM-B Model

PRIME[24] theory was developed to integrate numerous motivation theories and models, into one coherent framework. According to the theory, the "decision to do something will not result in action unless it generates the desire to do it at the relevant moment" (West and Michie, 2019). PRIME theory places emphasis on strong voluntary desire to transition to sustainable energy sources, as a key predictor of human behaviour (West and Michie, 2020), and the formula for "wider lifestyle shifts" (Nash et al., 2017). To actualise the theory, many researchers adopt the COM-B model (Michie et al., 2015, West and Michie, 2019, West and Michie, 2020). We used the model to help us understand what the household's intention is and how this intention can be activated to get the target behaviour. The COM-B model (see Fig. 1) consists of three main components, leading to a certain behaviour: capability, opportunity, and motivation.

Capability refers to a person's knowledge, skills, physical strength, and mental stamina to act. It is the individual's or household capacity to proceed with the energy transition, both physical (e.g., physical skills, stamina, or strength) and psychological (e.g., understanding or memory).

Physical capability was operationalised by adopting the Michie et al. (2015) approach, where individual skills (including knowledge) that enable a person to perform the target behaviour. We assessed whether the household had knowledge of the municipality energy policy, alternative energy options, home insulation options, approximate cost of the transition, how to mobilise resources or where to get professional support. Physical strength and stamina were not operationalised in this study since it is beyond the scope of this study.

[24] Planning, Response, Impulse / Inhibition, Motive and Evaluation Processes.



CAPABILITY: An attribute of a person that together with opportunity makes a behaviour possible or facilitates it.	PSYCHOLOGICAL CAPABILITY: Capability that involves a person's mental functioning (e.g., understanding / social skills / memory)
OPPORTUNITY: An attribute of an environmental system that together with capacity makes a behaviour possible or facilitates it.	REFLECTIVE MOTIVATION: Motivation that involves conscious thought processes (e.g., plans and evaluations / beliefs)
MOTIVATION: An aggregate of mental processes that energise and direct behaviour.	AUTOMATIC MOTIVATION: Motivation that involves habitual, instinctive, drive related and affective processes (e.g., wants, needs, inhibitions, reflexes, and impulses)
BEHAVIOUR: Individual's human activity that involves co-ordinated contraction of striated muscles controlled by the brain	PHYSICAL OPPORTUNITY: Opportunity that involves inanimate parts of the environmental system and time (finances / material resources / location / physical barriers)
PHYSICAL CAPABILITY: Capability that involves a person's physique, and musculoskeletal functioning (physical skills / knowledge / stamina / physical strength)	SOCIAL OPPORTUNITY: Opportunity that involves other people and organisations (interpersonal influences / culture / social norms)

Fig. 1. COM-B model of behaviour, modified from West and Michie (2020)

Psychological capability was operationalised by assessing whether households clearly understood three key components that have an impact on their future behaviour. First, their municipalities energy transition policy including the proposed alternative energy transition solution(s) (hydrogen, solar, wind etc.). Second, a clear understanding of the municipality's role (information provision / facilitation / resource mobilisation / actual implementation of the energy transition etc.). Third, whether the households understood their role in the energy transition. These three psychological capability questions are important because in 1959 when a large gas field was discovered in Groningen, cooking, hot water, and heat transition , in 98 percent of the Dutch households, was financed, managed, and driven by the government (Raad voor de

Leefomgeving en Infrastructuur, 2017, Ministerie van Economische Zaken, 2016, Verbong and Schippers, 2000). Fifty-nine years later, Dutch residents are facing a new form of energy transition. This time, the government does not have financial resources to implement top-down gas discontinuation, as they did in 1963. More than 7.5 million Dutch households with gas connections are expected to play a major role in the transition (Ebrahimigharehbaghi et al., 2019). Since the switch from coal to gas is still in the minds of the older generation, they may expect the same or even greater support from the government in the current transition (Dekker et al., 2016). Psychological capability questions aim to increase understanding of how citizens feel about being the main drivers of an energy transition process, to fulfil a climate change commitment, they did not make. People's psychological mental functioning and memory were not operationalised since they are beyond the scope of this study.

Opportunity refers to external factors, both physical (subsidies, grants, loans, or time) and social (e.g., social cues, interpersonal influences, and cultural norms) that facilitate homeowners' transition. We operationalised physical opportunity by asking three key questions. First, whether the households have time to look for various contractors to help them with the transition. Second, whether they can arrange another accommodation to go to when the contractors are renovating their homes. Finally, whether they received practical information from the municipality on the possibilities available for them to facilitate the transition. Social opportunity questions focused on two key areas. First, whether the households know people in their neighbourhood who have already started making energy transition changes in their homes (insulation, ventilation, solar panels, or induction cooking). We assess whether they had a chance to watch and be influenced their neighbours, as they installed various energy solutions, in accordance with the Cialdini and Goldstein (2004) social influence theory. The second question assessed whether switching from cooking with gas to induction / electric cooking is a problem. Induction or electric cooking is placed under social opportunity because previous research confirms the existence of cultural norms associated with natural gas cooking which is considered superior to induction cooking, that may hamper the transition process (Steenbekkers and Scholte, 2019).

Motivation is at the core of the conceptual framework (Fig. 1) and the fuel that drives change (Michie et al., 2011, Michie et al., 2015). It is the internal driving force for taking actions to discontinue gas use. Motivation is either automatic (wants, needs, inhibitions, reflexes, impulses / automatic imitation) or reflective (beliefs of what is good or bad and planning). Reflective motivation was operationalised by asking three key questions. First, whether the respondent believes that transitioning away from natural gas is good for the environment. Second, whether they believe that transitioning from natural gas would cost more than what they are incurring currently. Lastly, we enquired whether the respondent wants their neighbourhood to quickly transition. The first two questions fall under evaluations (belief system), whereas the third question falls under the planning part of reflective motivation. We assumed that if the respondent wants a swift transition, there is a high probability that they already started the mental process of assessing the impact of this decision on their household. Automatic motivation was assessed using four questions. The first question on whether they want to save their energy bill focused on their desires (want or need) or motives. The last three questions assessed the degree of influence by positive experiences from the (1) internet, (2) relatives and friends, and (3) neighbours. These questions were categorised under automatic motivation because the interactions may induce automatic imitation.

2.3 Behavioural change wheel and Behavioural Change Interventions (BCW)

The Behavioural Change Wheel (BCW) is a compilation of nineteen (19) behavioural change frameworks. None of these frameworks comprehensively characterised interventions or linked them to a systematic and holistic assessment of target behaviour. From these 19 frameworks, a three-tier wheel was developed. The hub of the wheel explains what behaviour needs to change, and comprises of three components (capability, opportunity, and motivation) and six sub-components (as explained in sub-section 2.2).

After detecting what needs to change, the middle layer, comprising of nine behavioural change intervention (BCI) functions, identifies the best approach to realise the change. The nine BCIs are education, persuasion, incentivisation, coercion, training, enablement, modelling, environmental restructuring, and restrictions. Education refers to an action aimed at increasing knowledge and understanding of the ongoing energy transition strategy, process, roles, responsibilities, and planned actions. Persuasion is the stimulation of energy transition actions or inducing feelings, whether positive or negative. Incentivisation creates an expectation of reward whereas coercion creates expectation of cost or punishment. Training occurs when there is an impartation of energy transition skills e.g., skills on the various energy sources or how to develop a home improvement plan that focuses on sustainable energy sources. Restriction is the use of rules to prohibit or reduce the engagement in competing behaviours. For instance, prohibiting future installation of natural gas infrastructure in newly constructed houses. Environmental restructuring occurs when the social or physical context is modified to encourage behaviour change. Modelling is when an example is presented for aspiration and imitation. Finally, enablement is when barriers to energy transition are reduced and means for successfully transitioning are increased. In Netherlands, the provision of energy coaches to support households in making complex energy transition decisions is a form of enablement.

The final layer contains seven policy categories: communication / marketing, legislation, regulation, fiscal measures, guidelines, environmental/ social planning, and service provision. Policy guidelines are not the focus of this paper.

The first layer of the BCW (COM-B model of behaviour) has two main functions. First, it ensures that when designing interventions, designers do not focus on one layer (individual or system). Second, COM-B model highlights the inter-dependence of behaviours to ensure the design of interventions that target a set of behaviours, instead of focusing on only one behaviour. The model treats behaviour as a system comprising of sets of inter-dependent behaviours. In the research context, transitioning to sustainable energy sources is interdependent on being able to raise resources to make the transition and understanding viable energy alternatives.

Each BCI is closely linked to the COM-B (see Table 1). Physical capability is increased through training and enablement whereas psychological capability is enhanced by training enablement and education. Both physical and social opportunity are increased by enablement, restriction, and environmental restructuring. Moreover, training enhances physical opportunity and modelling increases social opportunity. Automatic motivation is increased using all the interventions except for education and restriction. Reflective motivation is enhanced through education, persuasion, incentivisation and coercion.

Table 1. Matrix on linkages between COM-B and BCIs, source (Michie et al., 2015)

COM-B components / Intervention Functions	Education	Persuasion	Incentivisation	Coercion	Training	Restriction	Environmental Restructuring	Modelling	Enablement
Physical capability					■				■
Psychological capability	■				■				■
Physical opportunity					■	■	■		■
Social opportunity						■	■	■	■
Automatic motivation		■	■	■	■		■	■	■
Reflective motivation	■	■	■	■					

Applied, the COM-model provides insights in what should be altered to influence and change current behaviour. In addition, the linkages between the three COM-B components and the BCI provide a unique opportunity to propose interventions specifically targeted to influence the factors that lead to behavioural change, in a systemic manner.

3 Materials and Methods

The results of applying the COM-B model are sensitive to varied contexts, spaces, and time. Meaning, you might get different results when focusing on another subject matter, in another place in the same country or another country and at a different decade or century. Therefore, data and results should be understood in their context and the context described well. Also, researchers should understand what results are transferable to other contexts. Therefore, the materials and methods section start with a short case-study description, to provide sufficient context of the neighbourhood where we conducted the research.

3.1 Austerlitz case study

Austerlitz is a neighbourhood in Zeist Municipality, in the central province of Utrecht. It is a mixed neighbourhood (buildings with diverse years of construction) with a housing stock of 656 households in 2019 (see Fig. 2) and about 800 in 2021 (de gemeente Zeist, 2021a). The homes in Austerlitz are divided as follows: 39% are semi-detached houses (twee onder een kap); 31% are terraced houses (rijtjeshuis); 20% are free-standing houses (vrijstand); 5% are small flats (onder en boven) and 5% are diverse e.g., business premises (Austerlitz Duurzaam, 2019).

The neighbourhood has houses as old as 1805 and new houses that were constructed recently. In 2020, approximately 100 homes were constructed in Austerlitz, some with gas connection and others were natural gas-free (de gemeente Zeist, 2021b, de gemeente Zeist, 2021a). A majority (90%) of the homes are owned by individual households. There is a high level of risk for these households if renovations do not lead to a return on investment. There is a large diversity in real estate values (see WOZ[25] in Fig. 2) of the houses, depicting financial diversity and system complexity.

Austerlitz building density is low. Thus, a heat network (also known as district heating or "warmtenet") has little chance of success (de gemeente Zeist, 2021b). Moreover, the neighbourhood has exceptionally old houses and monuments, that require a higher temperature heat output. Thus, application of heat pumps is problematic, unless first, the insulation is improved. Insulation is expensive for detached houses; there are walls to be insulated on four sides. On the other hand, the energy bill is often high, that residents may consider changes that could reduce current costs. Also, insulation and ventilation make the homes more comfortable. Homeowners should decide whether to deploy far-reaching insulation and heat pumps or replace natural gas with green gas (hydrogen or biogas).

[25] WOZ refers to the Real Estate Valuation (WOZ) for the buildings. The municipality determines the WOZ value of a house based on an appraisal. Source of WOZ information: Belastingsamenwerking gemeenten & hoogheemraadscap Utrecht (BghU), 1-1-2017

Description	Numbers	Unit
Residents	1581	persons
Men	801	persons
Women	780	persons
Residents 0-15 years old	209	persons
Residents 15-25 years old	182	persons
Residents 25-45 years old	302	persons
Residents 45-65 years old	572	persons
Residents 65 and older	316	persons
# of Households	656	households
One person Households	162	households
Households without children (<18jaar)	333	households
Households with children (<18jaar)	161	households
Average # of persons per Household	2,4	persons
# of buildings	617	buildings
Average # of persons per Household	2,6	persons
Minimum WOZ value	55.000	euro
Maximum WOZ value	892.000	euro
Average WOZ value	319.170	euro
Number of WOZ objects to be used as a home	617	buildings
Owned by a natural person	532	addresses
Not owned by a natural person	92	addresses

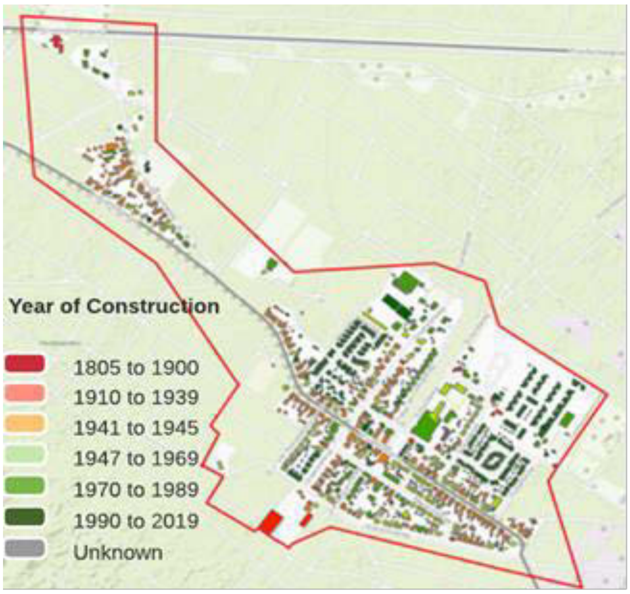


Fig. 2. Austerlitz Demographics and Map of houses (Source: Zeist municipality)

The Heat Transition Vision (de gemeente Zeist, 2021b) and the residents guide (de gemeente Zeist, 2021a) outline the following proposed renovations for the Austerlitz homeowners:

1. Insulation of cavity walls, roofs, and windows. The municipality informs the residents that hydrogen gas may not be cheaper than natural gas unless the house is well insulated to reduce drafts and prevent heat loss.
2. Floor insulation (recommended if there is a good crawl space).
3. Sustainable (demand-driven or with heat recovery) forms of ventilation.

The above-mentioned upgrades to an existing house so that it can meet contemporary or future conditions, this are referred to as retrofits. In this paper, the term retrofit is the equivalent to home renovation or restoration and not the same as routine repairs and maintenance.

3.2 Participants and procedures

3.2.1 Participants

Participants in the 19 kitchen interviews are homeowners (no tenants selected). Selection was based on housing types and participant’s profile. Majority of the participants are male, above 45 years, and earn reasonable annual income (Fig. 3).

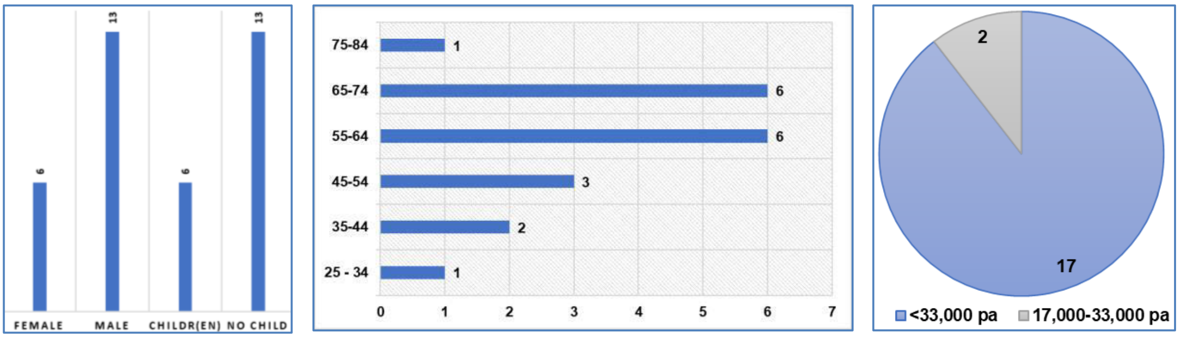


Fig. 3. Demographics (a) gender, houses with children, (b) age, and (c) income.

Most of the participants have no children living in the household. Six out of 19 participants do have children. Most participants are well educated and employed.

3.2.2 Procedure

The 19 one-hour interviews were conducted for ten days, in the participants kitchens, over a cup of coffee or tea, between the 4^{th} to the 19^{th} of March 2021. Participants were briefed for 10 minutes on the purpose of the interview, their role and how long it would take. Then the interviewers explained how the researchers will manage personal data and their consent was elicited.

Interviews were conducted in Dutch and the interviewers completed the answers in online forms. The questions asked during the structured interviews and the participant responses are available as supplementary material (Onencan and de Koning, 2022).

3.3 Measures

The structured interview consisted of 20 questions. The first part assessed the nature and extent of social influence. Follow-up questions probed participants perceptions concerning different energy sources. Then we assessed the capability, opportunity, motivation, and behaviour of each participant. Final questions gathered individual and household demographic data. The COM-B variables are presented in Table 2 and discussed below.

Table 2. COM-B variables to measure the intention – action gap

Construct	Variable	Type	Variable measurement
Capability	Physical capability	Interval: continuous	4 Point Likert scale
	Psychological capability	Interval: continuous	4 Point Likert scale
Opportunity	Physical opportunity	Interval: continuous	4 Point Likert scale
	Social opportunity	Interval: continuous	4 Point Likert scale
Motivation	Reflective motivation	Interval: continuous	4 Point Likert scale
	Automatic motivation	Interval: continuous	4 Point Likert scale
Behaviour	Homeowner behaviour	Nominal: dichotomous	0=No; 1=Yes

We used a 4-Point Likert scale for the subjective assessment of all the COM-B components, with options ranging from strongly disagree to strongly agree. We did not incorporate the neutral option because we wanted to get clear-cut responses on the participants perceptions. The current behaviour was assessed based on four elements, namely whether the participant has: (1) energy saving gadgets; (2) engaged in energy saving actions (e.g., switch of lights and sockets when not in use); (3) invested or applied for a loan or grant to start the transition process; and (3) a renovation plan that takes account of the transition.

4 Findings

In this section, we provide the results of the interviews on the participant's preferred energy source (section 4.1), current behaviour (section 4.1), capability (section 4.2), opportunity (section 4.3), and motivation (section 4.4).

4.1 Behaviour

4.1.1 Preferred Energy Source

The energy solutions, under consideration, for Austerlitz are: (a) green gas / hydrogen via the natural gas pipelines; (b) solutions with heat pumps (air heat pumps, or soil heat pumps with (shared) bottom loops), for all homes and buildings; and (c) a solar collector or PVT panel as a collective solution (de gemeente Zeist, 2021b, de gemeente Zeist, 2021a).

Based on the results of the kitchen interview, the generally preferred energy source is all electric. One of the participants stated that their preference will vary "*depending on energy tax, investments, energy prices*", (external opportunities). The main challenge people see with an all-electric energy source, is that it is too expensive, the temperature (not warm enough), and reliability. Homeowners fear that electricity might be depleted during winter season, with no contingency plan or sufficient storage. Hydrogen is the second preferred option because it may lower their current bills and it is considered the highest temperature source for heating. According to the 19 interview responses, hybrid solutions are the most reliable, their warmth is at acceptable levels, and they are perceived not to be very expensive. The main challenge with hybrid systems is safety. However, if the municipality is considering Hydrogen as a viable option, green-gas acceptance levels are considerable. One participant added that safety is not an issue because "*Everything is equally dangerous if used incorrectly*." The main issue that the municipality may need to address is the expense of replacing natural gas with hydrogen.

4.1. 2 Current Behavioural Actions

All possible energy solutions require complementary home retrofits to ensure that the house is safe, warm, and comfortable. Figure 4 contains responses to the interview question: Have you already done any of the following to improve your home?

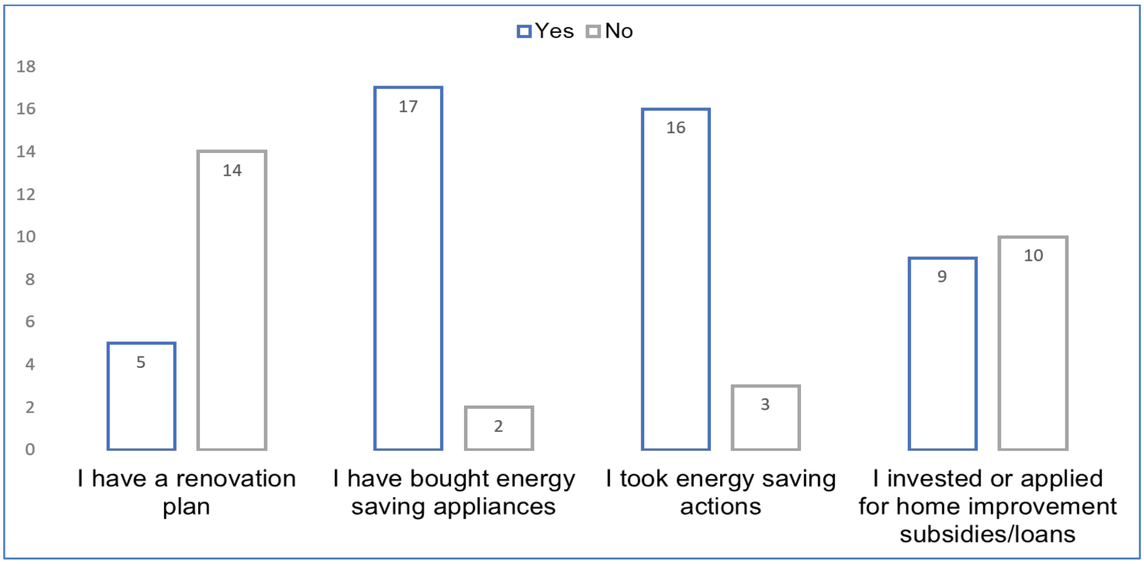


Fig. 4. Homeowners' current behaviour

The most practiced (89%) behaviour is purchasing sustainable appliances (LED lamps, refrigerator with high energy label, water-saving shower head), closely followed (84%) by changing energy use behaviour (thermostat lower, lights off, etc.). Then investing or applying for grants or loans to improve their home and finally, the least action (26%) was developing a home renovation plan, e.g., to upgrade heating, ventilation, and air conditioning equipment.

The first two highest responses (energy saving gadgets and actions) indicate that the participants are highly engaged and motivated for short-term energy saving. However, the main challenge is their approach to long-term change (e.g., developing a home renovation plan, consistent with ongoing energy transition processes); it is piecemeal, and not systemic.

4.2 Capability

The questions related to capability were divided into two parts, physical capability mainly focusing on homeowner's skills needed to be able to make the transition (Fig. 5.) and psychological capability that assesses homeowner's understanding of the goal and responsibilities of various energy transition actors (Fig. 6.).

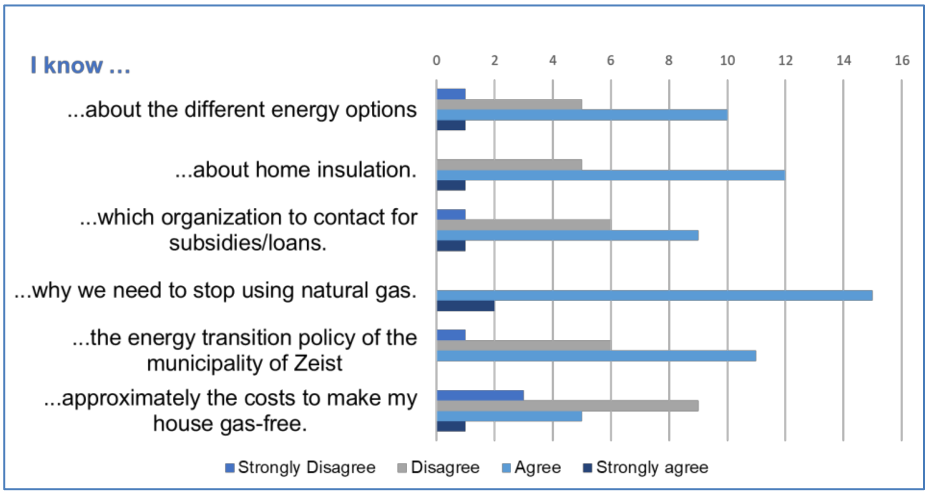


Fig. 5. Homeowner's skills (physical capability)

Analysis of the participant responses to the capability question indicate higher levels of psychological capability compared to physical capability (Fig. 5 and 6).

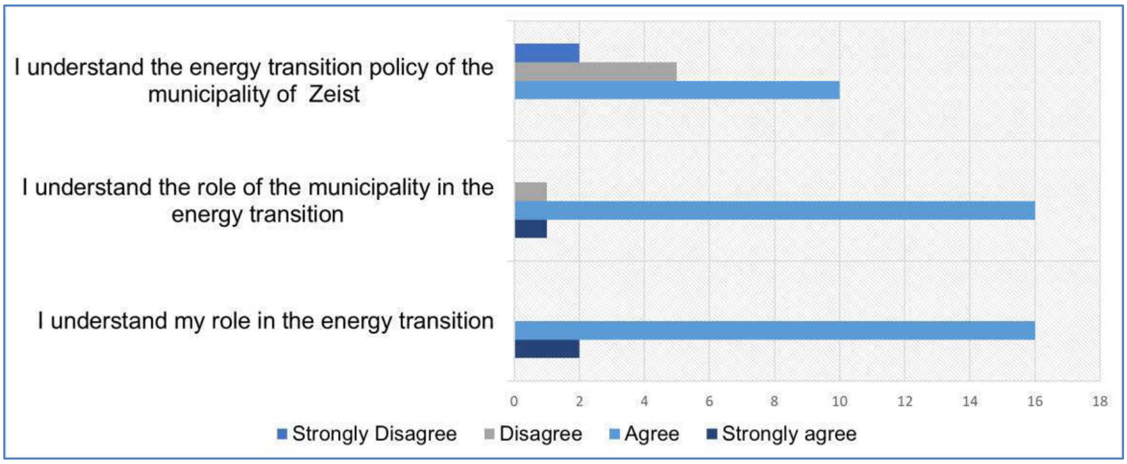


Fig. 5. Homeowner's understanding of the transition (psychological capability)

Every participant knows why the Netherlands should stop using natural gas. More than half of the participants agree that they know: (1) different energy sources; (2) how to insulate their homes; (3) what organizations to contact and (4) the energy transition policy for Zeist municipality. The homeowners do not have sufficient knowledge on the approximate costs of making their house gas-free, which indicates a lower level of perceived behavioural control (Fig. 5.). The results in Figure 6 indicate that the role of the municipality and individual household's roles are rather well understood, but less so the energy transition policy.

4.3 Opportunity

Opportunity questions (Fig. 7) were divided into two parts: physical (influenced by the environment) and social (influenced by interpersonal relations). The first three questions focus on physical opportunity while the last two on social opportunity. Social opportunity is stronger than physical opportunity because most people know of their neighbours who have initiated the energy transition process and there is positive social influence on electric / induction cooking in the neighbourhood.

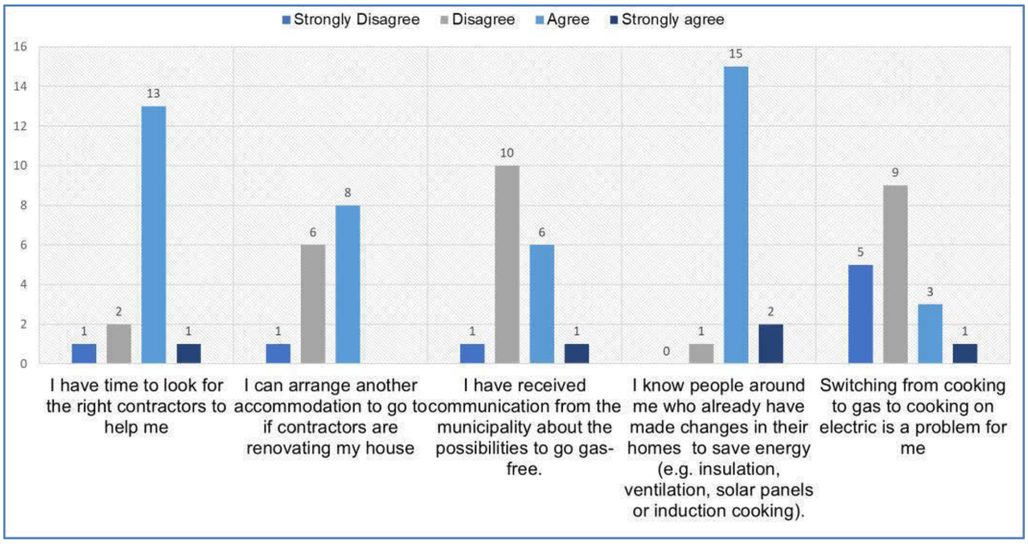


Fig. 7. Individual homeowners' opportunity

The interview data shows that the time it takes to look for a contractor is not a real issue for many people. However, arranging alternative accommodation might be more problematic. About half of the participants confirm that they have not received communication from Zeist municipality about the possibilities of becoming gas-free. However, many people indicate that they know neighbours who have energy transition expertise, these people are potentially strong influencers of the motivation of other individuals (Fig. 7). Finally, moving towards gas-free cooking is not perceived as problematic by most (Fig. 7).

4.4 Motivation

The results on the three factors measuring reflective motivation were diverse (see Fig. 8). Most of the interviewees believe that transitioning away from natural gas is good for the environment but the thoughts on if the neighbourhood should transition are less positive. Moreover, many people are convinced that home retrofits or alternative energy solutions will cost them more money than they spend now. These results show that money in terms of costs of energy transition contributes to uncertainty (see Fig. 5, responses to the last question).

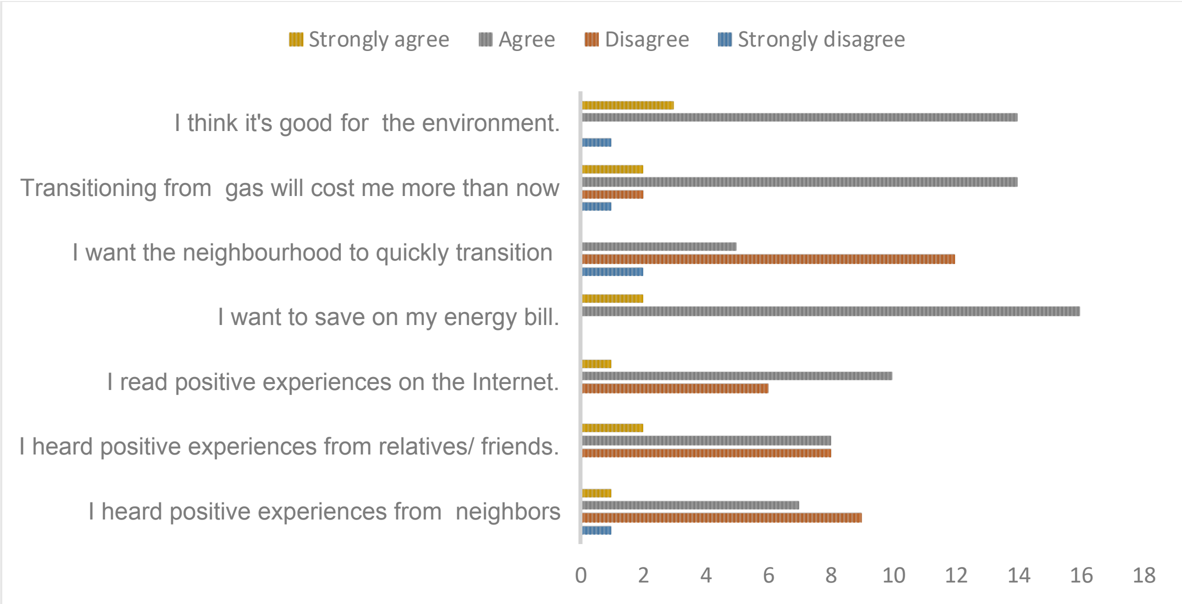


Fig. 8. Motivation to transition to renewable energy sources

Under automatic motivation, people are motivated to transition to make savings on their energy bill. Reduced energy bills are a positive desire (whether a want or need) and clear motive for the desired behaviour. According to the other automatic motivation results, the positive social influence from neighbours, relatives and friends is not compelling. The percentage of people who agree and disagree are comparable. However, the interviews and case study material do show that there is a strong social network in the neighbourhood. But it is not clear from the results whether people have not heard any positive experiences because they do not exist or because the negative experiences overshadow the positive. Interestingly, social influence through internet seems to play a slightly larger role in positive messages than face to face social influence for the participants.

5 Discussion & Conclusions

The paper answers two research questions: (1) what source of energy transition behaviour (capability, opportunity, and motivation) could activate systemic behavioural change at the household level? (2) what BCIs best address the identified system of behaviours? The results of both questions are discussed in Subsections 5.1 and 5.2. Subsection 5.1 discusses specific behaviour that needs to change and proposed interventions to enhance resident capability, opportunity, and motivation for Zeist municipality and similar organisations. Subsection 5.2 explains the scientific contribution of this paper in reference to the behaviour that needs to change and its subsequent interventions. In section 5.3 we discuss how we mitigated the research limitations we faced.

5.1 Contribution to Practice

Results indicate that currently Austerlitz residents generally have a positive attitude towards the energy transition but are mostly focused on short-term solutions and the monetary costs and benefits of the energy transition. Most of the interviewees believe that transitioning away from natural gas is good for the environment but they are not always convinced it will lead to monetary benefits for themselves. Therefore, future interventions, in Austerlitz and similar local authorities, should also target other facets of reflective motivation (goals and intentions). Target interventions could be a combination of education, persuasion, coercion (e.g., regulations, guidelines, or fiscal measures to deter gas usage) and incentivisation (e.g., tax free benefits, grants, subsidies, loans, free advisory services, and free gadgets) (Michie et al., 2015). Interventions should focus on enhancing homeowner's belief that action towards the energy transition is beneficial for them, to motivate them to incorporate it in their long-term retrofit plans. Also, interventions should enhance homeowners' motivation for long-term engagement in energy transition, not only as key players, but as main drivers of change. Education and persuasive interventions may also consist of reframing issues, to change homeowners understanding of the behaviour that needs to change. Automatic motivation of saving the energy bill and reducing the energy transition costs is a key concern and one of the primary drivers of behavioural change. Moreover, the positive social influence from neighbours, relatives and friends needs to be tapped to bridge the intention-action gap. To address automatic motivation, the municipalities need to prepare a combination of interventions that persuade, incentivise, coerce, train, enable, structure the environment and model the desired behaviour so that automatic imitation can be induced (Michie et al., 2015, Michie et al., 2011). These interventions should focus on a system of behaviours as opposed to one behaviour (Michie et al., 2015). Since money is a (de)motivating factor, the central government and municipalities should consider the option of shifting a large bulk of the energy transition project and advisory related budget allocations towards supporting households that do not have the resources to implement energy transition (incentivisation). In addition, households should be enabled, and the policy environment restructured to facilitate more opportunities and access to tax benefits, tax reliefs, energy transition loans, and free or discounted energy gadgets.

Related to that, the opportunity factors should also be enhanced towards connecting small steps (buying energy saving appliances for example) to more and more elaborate steps. The behaviour that municipalities should facilitate is a shift, by homeowners, from piecemeal short-term actions, toward long-term oriented, systemic retrofits. Municipalities should especially focus on physical opportunity because it was weaker than social opportunity. This means that there should be a strong focus on providing training, restrictions, environmental restructuring to facilitate energy transition and enablement (Michie et al., 2015). As an intermediate measure, while Austerlitz is still waiting for a collective decision on the preferred energy source(s), the municipality could focus on promoting simpler, quick, win-win solutions like induction heating, but clearly linked to longer-term interventions. Showing these quick steps as part of a longer process and the gains it leads to, can enhance the overall belief in the benefits for the individual (motivation). This should lead to a certain buy-in and spillover effect towards other behaviours, in the long term. Next to that, working on providing ways to mitigate inconvenience during retrofits (long-term solutions) should open-up opportunities for people to make home renovation plans and execute them. Also, to increase social capability amongst relatives, friends and neighbours (which was lower than internet), the municipality should incorporate modelling as one of its interventions for changing the current behaviour (Michie et al., 2015). One effective way to use modelling is through interactive gaming simulation where energy networks for every household can be built and strengthened in both the virtual and physical environment (Barrios-O'Neill and Hook, 2016). Last, since the focus of many people is on the monetary aspects, the opportunities offered should clearly address the financial aspects of energy transition.

Under capability fall the psychological and physical aspects of being able to engage in a behaviour. This means the knowledge needed, but also the possibility for someone to engage in actions and routines that go with the energy transitions actions. What we see, and what many other studies before us found, is that there is an intention-action gap. Many people believe that transitioning away from natural gas is a good thing. People now, more than ever, have the intention to act (even more so with the current situation of the gas prices increasing and the instability due to the war in Ukraine, though our study was done prior to this). However, people often do not know how. As a municipality it is crucial to provide this information. We acknowledge the limitations of information provision; alone information can never start a transition. However, we did find a perceived lack of information provision from the municipality so far. Half of the people indicated that they did not receive information from the municipality, and even less so say that they understand the policy of the municipality.

Participant responses to the capability question indicated higher levels of psychological capability compared to physical capability, which means that the target interventions should focus less on education and more on training and enablement (Michie et al., 2015). Education increases knowledge or understanding, whereas training moves a step further and imparts specific skills. Enablement involves tailored support (e.g., provision of an energy coach to guide households throughout the transition process) to increase the household means and reduce capability barriers (Michie et al., 2015, Michie et al., 2011). The results show that the monetary aspect for the capability component is uncertain. People do not know exactly what the costs will be. Also, the costs and benefits of going all-electric is not clear to people. Since all the houses are built in different years, and have different energy, insulation and ventilation needs, a tailored approach (enablement) is highly recommended, where energy coaches are assigned to households and paid by the municipality. These coaches, though specialised in alternative energy solutions, should also be able to: calculate the costs of the transition based on each household, connect households to reputable contractors, identify good quality products (e.g., solar panels), and have knowledge on financial services for households (grants, loan facilities and subsidies). These coaches or the municipality should also train households through imparting critical energy transition skills (e.g., a complete training on solar power that assesses benefits, viability, tax credits, other incentives, installation, costs, and maintenance). Moreover, municipalities should consider one-stop-shops where homeowners access relevant energy transition information, easily and fast. The municipality should send out regular communication, even when the future is uncertain, and the information on the possible energy solutions is not clear-cut. Future information provision should also address the capabilities towards higher perceived behavioural control. These may include having 'show' or 'display' houses, installing an energy neighbourhood exchange network, and highlighting inspirational stories of residents that have transitioned on the municipality website.

In conclusion, we suggest that municipalities connect their energy transition plans to current renovation plans of their residents, to comply with current beliefs and desires of cost saving, comfort, and aesthetics. Similarly, small steps should be clearly part of a long-term plan, easy next steps should be offered, and comprehensible stepwise action plans developed, starting small but leading to larger changes in the future. More transparency in the monetary aspects, financial enablement and support in inconvenience during retrofits should increase the opportunity and ability for people to act. Last, interventions should enhance homeowners' belief that energy transition is an intrinsic part of their long-term home renovation plans, to motivate them to drive the energy transition process. This may enhance homeowners' long-term engagement in energy transition, as the main drivers of change.

5.2 Contribution to Science

According to West and Michie (2020), there are two major actions that need to take place when applying the COM-B model: (1) capability and opportunity are the gates that "need to be open for motivation to generate the behaviour," and (2) there should be a spillover effect (negative or positive) between behaviour and the three sources of behaviour (capability, opportunity, and motivation). We will discuss these two effects, in reference to the results in this paper.

First question is: are the gates open for households to be motivated? The responses indicate that the doors are not widely open. Figure 5 shows that practical things like knowing the cost of the transition, and information on subsidies and loans is lacking but more general information like why they should stop using natural gas is readily available. This shows that information provision needs to be more specific and practical, oriented towards action. However, information provision is not enough to ‘open the gates’ and address systemic problems (Karvonen, 2013). The static nature of knowing limits its ability to lead to systemic changes - knowledge alone is not enough. Interventions should focus especially on enhancing household capabilities through increased understanding. Understanding is a social process, which occurs through active learning (Metcalfe and Ramlogan, 2005, Onencan and Van de Walle, 2018, Onencan, 2019). Active learning enables the homeowners to actively engage with the municipality, contractors, banks, financial institutions and other providers, in the process of constructing knowledge and sense making (Karvonen, 2013). Shroff et al. explain that active learning “*gives learners the opportunity to utilize their cognitive and higher-order skills and strategies by creating meaning from their experiences and the environment and from thereon, constructing their own knowledge and understanding* (Shroff et al., 2021).” To accelerate the energy transition, the focus should be on interventions that increase understanding of practical aspects of the transition. According to Michie et al. (2015), such interventions may include: modelling (demonstration of target behaviour), participatory environmental restructuring and participatory enablement of energy communities.

Second question is: do current behavioural actions, as presented in subsection 4.1.2, lead to positive spillover effects. Behavioural spillover theory is suggested when a set of behavioural changes are expected, leading to wider lifestyle adjustments. The theory proposes that engagement in one voluntary energy transition action could catalyse residents to make “wider lifestyle shifts beyond piecemeal” adjustments (Nash et al., 2019). The first two responses (energy saving gadgets and actions) indicate that the participants are highly motivated to change the current energy environment. However, the main challenge is their approach to change; it is piecemeal, and not systemic towards the more effective retrofits. Based on the responses, we assume that past interventions focused solely on technical issues (energy efficiency and carbon reduction) and barely tapped into other factors that influence people to make the change (aesthetics, safety, convenience, and comfort). Research indicates that to achieve widespread retrofit, homeowners should focus less on piecemeal technical solutions and more towards a systemic, long-term oriented approach that combine social and technical aspects (Karvonen, 2013, Karvonen, 2018, Kieft et al., 2020, De Feijter et al., 2021). Long-term orientation places the renovation plan with the supporting finances at the forefront and the energy saving gadgets at the rear. Identifying the behaviour that would have a multiplier effect is imperative for the energy transition.

Last, the research concludes that there is untapped potential in using the COM-B model and the behavioural spillover theory “as a means of catalysing wider sustainable lifestyle shifts” (Nash et al., 2019). The COM-B model assumes that the target behaviour is known, which is not true, in most complex cases. The target goal of transitioning away from natural gas is known, but not to what exactly, there are still different options to choose from. Also, the initial target behaviour that can lead to

energy transition spillover actions was not known. Moreover, it was not known what interventions would lead to greater impact with less input.
In conclusion, there are different levels of systemic change proposed with the iceberg model (events, patterns/trends/ underlying structures, and mental models). The last level focusing on mental models seeks to transform mindsets. Taking this into consideration, this paper analyses the deepest level of these types of transitions using a transparent COM-B model of behaviour and nine intervention functions. We identify viable interventions that may lead to mindset changes combined with behaviour analysis to better understand what can be done to bridge the intention-action gap. The research contributes to the identified research intention-action gap, by identifying key interventions that should be enhanced to 'open the gate' for behavioural change and motivate or activate households to voluntarily engage in energy transition, in a long-term, sustainable, and systemic manner. This general idea we believe could be replicated in different contexts and challenges.

5.3 Study Limitations

We identified the main study limitations early in the research and sought four ways to mitigate them. First, Zeist municipality case study and Austerlitz neighbourhood in particular were not selected at random, and this may lead to selection bias (Maesschalck, 2016, Leys, 2016). This limitation was minimised by ensuring that we document all the characteristics of the case study, so that when other researchers seek to replicate the study, they understand the context within which it was applied (Leys, 2016). Second, interviewing 19 respondents in a neighbourhood with 656 households, would lead to under-coverage and exclusion bias (Sala and Lillini, 2017). To address this, we worked closely with the Zeist municipality and representatives of the neighbourhood to ensure that we selected households that represent the entire neighbourhood in terms of housing types, level of transition and demographics. Third, the selected case study approach with the use of structured interviews, in general, has limited external validity (Maesschalck, 2016). To address this gap we extensively describe the case study under the materials and methods section so that when researchers seek to replicate the study they should make this decision on a case-by-case basis (Ruddin, 2006, Firestone, 1993). Finally, to increase replicability and internal validity, we used a structured approach of asking the interview questions through a questionnaire (with a few open questions), which is available as supplementary materials together with the dataset on the 4TU.ResearchData portal under DOI: 10.4121/19709053.

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