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Doctoral dissertation submitted to obtain the degree of
Doctor of Architecture, to be defended by

Victoria Țăranu

DOCTORAL DISSERTATION

Mobilisation for energy renovation - the case for behaviourally-informed policies

Promoter: Prof. Dr MSc Arch Griet Verbeeck

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The PhD was a four-year journey, full of ups and downs, but overall a journey of personal and professional growth. I would have never probably start this journey if not the passion of my husband Roberto for research. Most of our common friends were doing PhDs and postdocs, so witnessing their experiences encouraged me to try it myself (now I know it was mostly due to the social norm pressure), while at the same time being aware of the difficulties that I will face.

In this journey I had the luck to have the best of companions that I could wish for, my supervisor Prof. dr. ir. arch. Griet Verbeeck. All the research outcomes presented in this thesis are the result of our common work, while the mistakes are most likely mine. The topic and approach of the PhD was also the idea of Griet and the interest expressed both by researchers and policy makers towards it proves that it was a good choice mostly because of its interdisciplinary aspect. Right from the beginning we have agreed to look at the policies regarding energy renovation taking into account findings from behavioural economics. We both shared interest and expertise in sustainable architecture and together we dived into new fields of knowledge for us such as economics, psychology, policy making and even philosophy.

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Initially the studies on the Flemish EPC were supposed to be undertaken on the version of the certificate that is in use. Because of the availability of the Flemish Energy Agency and of Mieke Deurinck it was possible to test the new version of the certificate instead, which was still in elaboration phase. This collaboration allowed slight timely changes of the new Flemish EPC based on the results before its release in January 2019.

The PhD path was full of both successes and failures, and I have shared them all with my officemates during the coffee breaks – Ann, Elke, Elke, Bart, Kathleine, Erik, Ermal, Godfrey, Ilse, Jasper, Naomi, Nick, Saul. I appreciate their feedback on my research and bureaucracy related issues as well as personal support. These coffee breaks would have not been possible without the fresh coffee of which Carine takes care daily and with whom I tried to share some short chats in Dutch.

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Thank you for everything and for always being there for me, Cedric.

Summary

In Europe buildings are responsible for 36 per cent of the total CO_2 emissions, therefore policies promoting energy renovation of the residential stock play an important role in tackling climate change. The mainstream approach is based on the principle that information provision and the economic incentives are enough to overpass underinvestment in energy efficiency upgrades of the dwellings. The present research challenges the assumptions of traditional policies of rational choice and takes into account evidence regarding behavioural failures such as bounded rationality (cognitive limitations), bounded willpower (self-control problems) and social preferences.

The current thesis consists of two parts – the first part investigates dual-process models (DPMs) and their implications to decision making in the context of energy renovation. DPMs assume two possible ways of processing information – system 1 thinking that is heuristic, fast and effortless and system 2 thinking that is deliberative, relatively slow and effortful. The first chapter presents a literature review of the DPMs and the results of a survey exploring the balance between the two types of thinking regarding five energy efficiency measures. Chapter 2 summarises the findings of a survey with homeowners interested in renovation consisting of two parts - ranking exercise and choice experiment.

The second part of the thesis focuses on evidence-based policies that take into account behavioural insights, using the Flemish energy performance certificate (EPC) as a case study. Chapter 3 presents the findings of a qualitative study consisting of a comparative study of nine European EPCs and a focus group with experts. Chapters 4 and 5 summarise the results of quantitative studies – laboratory experiments. The aim of these studies was to verify if different information framings of the certificate play a role in the comprehension and interpretation of the certificate and the willingness to renovate. The five chapters of the thesis are based on journal articles and a conference proceeding.

The outcome of the thesis presented in Conclusions is a framework for evidence-based policies, elaborated based on the case study of the new version of the Flemish EPC. The proposed framework goes beyond nudging, as behaviourally-informed policies should take into account external constraints in the design of the choice architecture and the full spectrum of available policies. Nevertheless, behaviourally-informed policies are still at an early stage, and both the assumptions and the methods used are yet to be revised and this thesis is a small step in this direction.

Index

List of abbreviations

BE – behavioural economics

BI – behaviourally-informed

COP21 – 21st Conference of the Parties to the United Nations Framework Convention on Climate Change in Paris, 2015

DPMs – dual-process models

EE – energy-efficient

EPBD – Energy Performance of Buildings Directive (EU Directive)

EPC – energy performance certificate

HVAC – heating, ventilation and air conditioning systems

nZEB – nearly zero-energy building

PV - photovoltaic system

RE – renewable energy

RCT – randomized controlled trial

Introduction

Context and problem statement

Energy renovation policies in the context of climate change

Due to climate change, present generations face ever increasing in frequency and intensity extreme climatic events, such as cold and heat waves, heavy precipitation, droughts (European Environment Agency, 2017) and rising sea levels that by 2050 would cause over 143 million migrants only within developing countries (Rigaud et al., 2018). The Paris Agreement signed by 174 countries and the European Union at COP21 in 2015 meant reaching an international consensus in the urgency to fight climate change, and commitment to take actions in order to ensure "*holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels*" (United Nations, 2015).

In Europe buildings are responsible for 36 per cent of the total CO_2 emissions (EC, 2018) and therefore play an important role in tackling climate change. After the previous Energy Performance of Building Directives (EPBD) of 2002 (EC, 2002) and 2010 (EC, 2010), the recast of 2018 reaffirms the EU commitment to achieve a decarbonised building stock by 2050 (EC, 2018). EU Directives were translated into National Renovation Strategies and a mix of policies at national, regional and local level. In spite of international commitment and allocation of resources, the EU member states fall short compared to the targeted 3 per cent of renovation rates, having reached 0.4-1.2 per cent, depending on the country (European Commission, 2018).The European building stock has a huge untapped potential to reduce its energy intensity since 40 per cent of the buildings have been built before the 1960s (BPIE, 2011) and 75 per cent of the building stock is estimated to be inefficient (EC, 2016). Most of the European countries, including Belgium have high ownership rates of over 70 per cent, see *Figure 1*. Additionally, in Flanders terraced, semidetached and detached houses (94.9 per cent) prevail over apartment blocks (ADSEI, 2018) therefore, the decision to renovate is usually an individual decision of the homeowner who is also the occupier. Even though the renovation process is often prolonged over a longer period of time, the decision to invest in a particular energy-efficient (EE) measure is considered in this study as one-off investment.

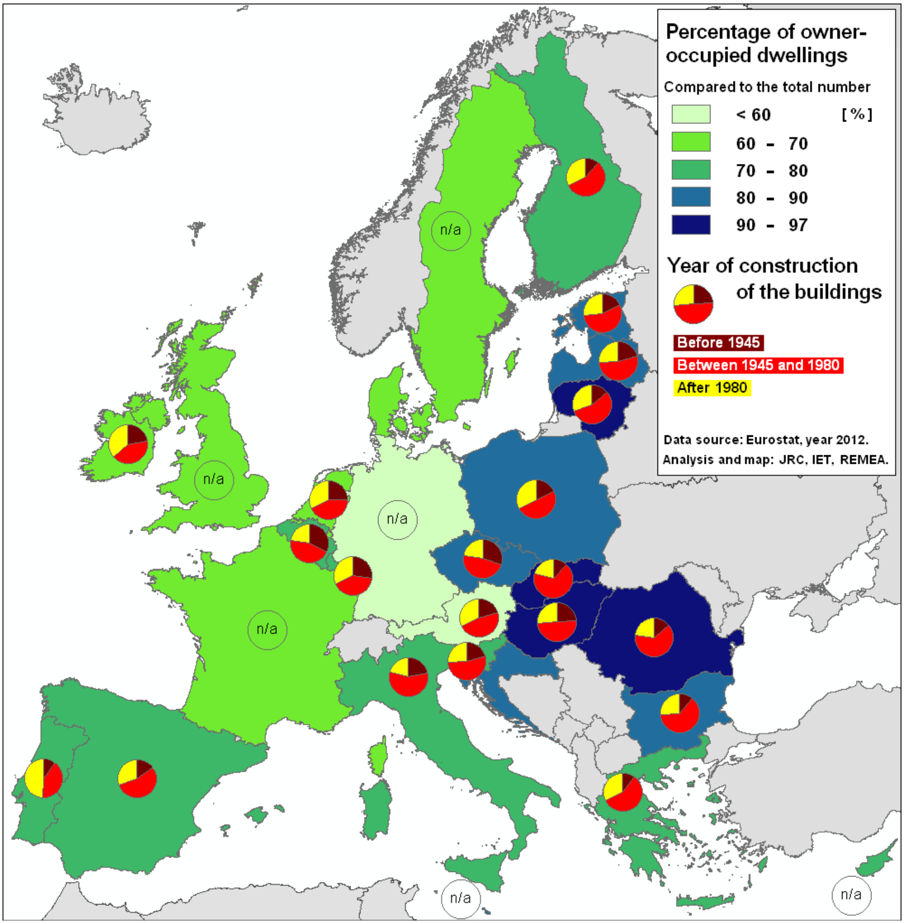

Figure 1 Tenure status of dwellings and their construction period in the EU. Retrieved from (Saheb et al., 2015)

Taking into account that EPBD gathers "*Long-term renovation strategies deliver the necessary progress towards the transformation of the existing buildings into nearly zero-energy buildings, in particular by increase in deep renovations*" (EC, 2018), in the present thesis by **deep energy renovation** is assumed a renovation aiming to achieve nearly zero-energy building (nZEB) levels. The strategy for renovation of the building stock consists in *"giving priority to energy efficiency,* *making use of 'energy efficiency first' principle as well as considering deployment of renewables.*" (EC, 2018)". Space heating is the main end-use in residential buildings in the EU (Saheb et al., 2015), thus the uptake of the following measures will be part of the thesis:

- Insulation of the building envelope – wall, roof, floor insulation and EE windows.
- EE heating, ventilation and air conditioning systems (HVACs), solar water heaters
- Renewable energy (RE) systems integrated at the building scale – photovoltaic systems (PV).

Traditional policies and behaviourally-informed policies

The mainstream approach to policies to encourage energy renovation is based on the principle that information provision and the economic incentives are enough to overpass the **energy-efficiency gap**, which is the fact that there is underinvesting in EE measures even when these are cost-effective (Ameli and Brandt, 2015). Therefore, the information campaigns and the economic incentives are set up with the assumption that dwellers have the capacity and willingness to maximize the utility (Allcott and Mullainathan, 2010). Nevertheless, the following market failures are well documented (Bubb and Pildes, 2014, The Committee for the Prize in Economic Sciences in Memory of Alfred Nobel, 2017, Sunstein, 2013):

- Market failures
    - Externalities
    - Asymmetric information
    - Market power (monopolies)
- Behavioural failures
    - Bounded rationality (cognitive limitations)

- Bounded willpower (self-control problems)
- Social preferences

Traditionally policies focus on market failures and address them with traditional policy tools such as taxes, incentives and information provision that are elaborated based on neoclassical assumptions of rational choice. Yet, evidence from the field of behavioural economics (BE) shows that people have a bounded rationality (limited knowledge, memory and computation power, uncertainty of the outcomes) (Simon, 2000a), and are affected by emotions (Finucane et al., 2000) and limited self-control (Ariely, 2008), the so-called behavioural failures. Evidence regarding behavioural failures should challenge the assumptions of policy making regarding decision making. Often policies rely on how homeowners should take decision based on perfectly computed cost-benefit analysis and these assumptions might affect the uptake of the environmental policy, for example financial incentives. Behavioural failures are also relevant in the context of how homeowners process technical information presented for example during campaigns promoting energy renovation or the information presented on the energy performance certificates (EPC).

Behavioural economics (BE) is "*a scientific discipline that applies psychological insights into human behaviour to explain economic decision-making*" (Lourenço et al., 2016) with the purpose to investigate how people actually take economics decisions, as opposed to how they are supposed to, according to "perfect rationality" and utility maximization function (Simon, 2000a). BE applies the findings from dual-process models (DPMs) to decision making in economic contexts. DPMs assume two possible concurrent and competing processing of information – **system 1 thinking** (or type 1 processes) that are heuristic, fast and effortless and **system 2 thinking** (or type 2 processes) that are deliberative, relatively slow and effortful (Evans, 2008). Literature review of the DPMs and factors influencing the balance between the two types of thinking is presented in Chapter 1. Behavioural insights of DPMs are of relevance for policy making because it allows the "*re-humanising the decision-making process*" (Jones et al., 2011) by taking into account human limitations.

In the present thesis by **behaviourally-informed policies** (BI policies) we assume evidence-based policies that take into account behavioural insights of DPMs, although in general BI policies could be based on findings of other behavioural models, not necessarily implying the duality of thinking. BI policies have the ambition to better understand the reasoning and mechanisms of decision making, taking into account bounded rationality, limited self-control that often lead to inconsistent decision-making.

BE investigates decision making in economic contexts taking into account system 1 thinking and should not be interchanged with the concept of nudging, see *Figure* 2. **Nudging** is an explicit application of findings from DPMs to policy making (see *Figure* 2) and regards exclusively non-coercive measures under the philosophy of "**libertarian paternalism**" (Sunstein, 2014). The definition of nudge gathers "*any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a nudge, the intervention must be cheap and easy to avoid.*" (Thaler and Sunstein, 2008).

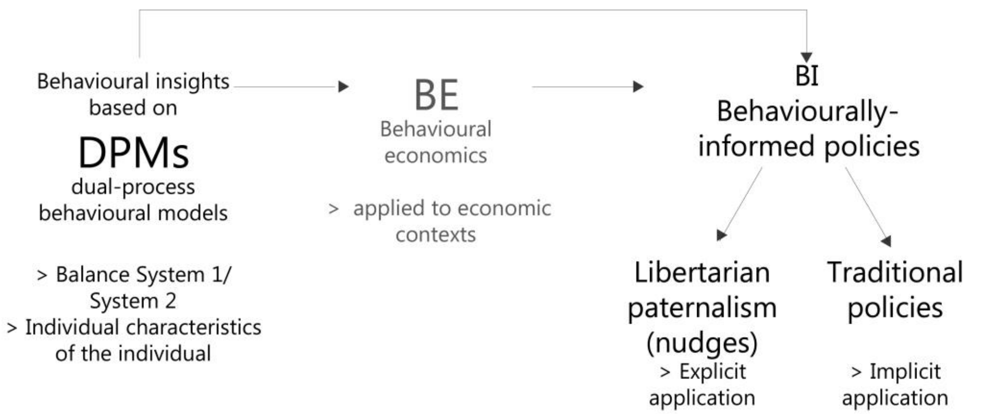

Figure 2 Distinction between behavioural insights, behavioural economics and behaviourally-informed policies

Since this definition does not refer to the key aspect of nudging – the assumptions regarding dual-process thinking, there is the risk of ambiguity in defining what qualifies as a nudge. According to Rebonato R. nudging implies "*a* *set of interventions aimed at overcoming the unavoidable cognitive biases and decisional inadequacies of an individual by exploiting them in such way as to influence her decisions (in an easily reversible manner) towards choices that she herself would make if she had at her disposal unlimited time and information, and the analytic abilities of a rational decision-maker, more precisely, of Homo Economicus*" (Sunstein, 2013). This definition refers to system 1 thinking and human limitations provided by BE and DPMs, yet does not include nudges that aim to avoid biases and enhance deliberative thinking, limiting only to nudges that exploit biases. Our alternative definition for nudge is "**a slight change in choice architecture that affects system 1 thinking or the balance between the two systems and steers behaviour towards a predictable direction**".

Advocates of nudging approach underline its cost-effectiveness compared to traditional policy tools (Benartzi et al., 2017), yet it is unclear how nudges can address structural barriers, such as lack of access to capital (Jones et al., 2011). Besides, certain policy might be effective on short term, but it might fail to address major problems on the long run. The following section will detail on the current state of BI policies and their limitations with a literature review regarding types of nudges and frameworks for elaborating BI policies.

Behaviourally-informed policies

Literature review of existing frameworks

According to Sunstein C. nudges classify into *educative* nudges and *noneducative* nudges (Sunstein, 2016). Educative in this context means that the nudge is intended to reframe the information in order to get a rational response, while noneducative nudges are intended to provoke a system 1 interpretation of information.

An alternative classification is offered by Baldwin R. (Baldwin, 2014a):

- First degree nudges, aiming to "*enhance reflective decision-making*", by avoiding an existing bias or by changing the choice architecture in order to incline the balance towards deliberative thinking, for example by making the information more salient and easy to process.

- Second degree nudges, aiming to "*to bias a decision in the desired direction*" by exploiting an existing bias, for example the default nudge.
- Third degree nudges aiming to motivate emotionally, for example graphic displays on cigarette packs.

The above proposed definition and classification of nudges of (Baldwin, 2014b) overcome the ambiguity of what qualifies as a nudge and will be used in the current research.

Libertarian paternalism (soft paternalism) is often used interchangeably with nudging (Sunstein, 2013) and pre-commits to freedom of choice (Bubb and Pildes, 2014). Even though there is no clear distinction but rather a continuum between soft and hard paternalism (Sunstein, 2013), the former usually excludes coercive policy instruments or economic incentives. For example, Sunstein C.R. provides the following examples of policies regarding soft and hard paternalism (Sunstein, 2013):

- Soft paternalism – fuel-economy label
- Hard paternalism – fuel-economy standards

Energy labels for vehicles aim to encourage the purchase of EE vehicles, at the same time allowing the freedom of choice. Yet, not all types of information provision qualify as nudging because it could also affect the *homo economicus*. Only certain information framing might qualify as a nudge within the energy label, if these avoid or exploit system 1 thinking. Even though the freedom of choice of the customer is guaranteed, the economic agents have to comply with the regulation, just as other nudges need a command and control measure with respect to economic agents in order to be implemented (Baldwin, 2014a).

Another framework for identifying nudges in the context of soft and hard paternalism is proposed by (Oliver, 2018), see *Figure 3*. The axes refer to the following aspects of the policy tools:

- ab axis Liberty (soft paternalism) – Regulatory (hard paternalism).
- ae axis Behavioural (BE assumptions) – Rational (standard neoclassical economic theory).
- ad axis Internalities (harms that people impose on themselves) – Externalities (harms imposed on society)

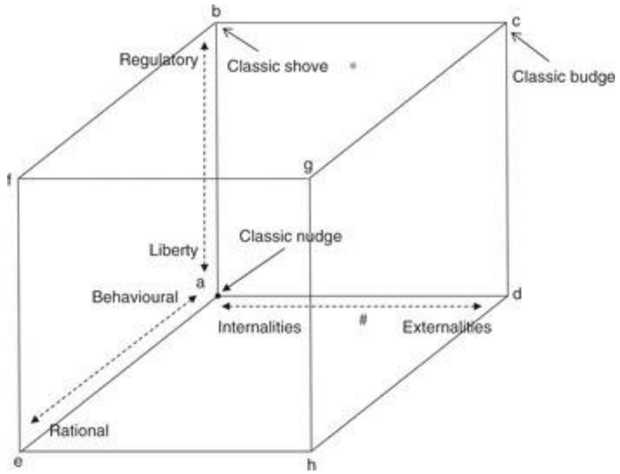

Figure 3 Distinction between nudges, budges and shoves - the behavioural policy cube. Retrieved from (Oliver, 2018)

The three types of policy interventions – nudges, budges and shoves assume dual-process thinking (Behavioural extreme of ae axis), see *Figure 3*. Nudges (a corner) as opposed to budges (c corner) and shoves (b corner) belong to soft paternalism (Liberty). Budges, as opposed to nudges and shoves, regard Externalities, behaviours that harm the society, not only personal lifestyle choices (Oliver, 2018). Yet, most of the behaviours that are object of policies, regard both Internalities and Externalities, for example the decision to renovate. It has implications at the individual level, such as "*higher comfort levels and wellbeing and improved health by reducing mortality and morbidity from a poor indoor* *climate*", as well as at societal level, such as lower CO_2 emissions, job creation, energy security (EC, 2016).

In the context of libertarian paternalism, various frameworks provide a list of possible nudges to be used as guidelines for elaborating BI policies. EAST method (Hallsworth et al., 2014), elaborated by the Behavioural Insights Team (The Behavioural Insights Team, 2018) provides the following guidelines:

- Make it Easy
    - Defaults
    - Reduce hassle
    - Simplify message
- Make it Attractive
    - Attract attention for example with the use of images
    - Rewards and sanctions
- Make it Social
    - Use the social norm for encouraging desired action
    - Encourage peer-to-peer collaboration
    - Public pre-commitment
- Make it Timely

MINDSPACE gathers the following recommended nudges: Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitments, Ego (Dolan et al., 2010).

Other frameworks such as Learn, Test, Adapt (Haynes et al., 2012) elaborated by Behavioural Insights Team (The Behavioural Insights Team, 2018) and BASIC (Hansen and Schmidt, 2017), elaborated by iNudgeyou (iNudgeyou)detail on the scientific method of conducting RCTs adapted to the audience of policy makers.

The acronym BASIC, see *Figure 4*, stands for (Hansen, 2018):

- *"Identifying and conceptualising relevant policy issues in terms of Behaviour.*
- *Analysing the behavioural challenges targeted.*
- *Identifying the relevant Behavioural Insights to apply as potential Solutions.*
- *RCT solutions through Intervention based on proper experimental designs.*
- *Implementing effective solutions as behavioural public policies through a structured phase called Continuation."*

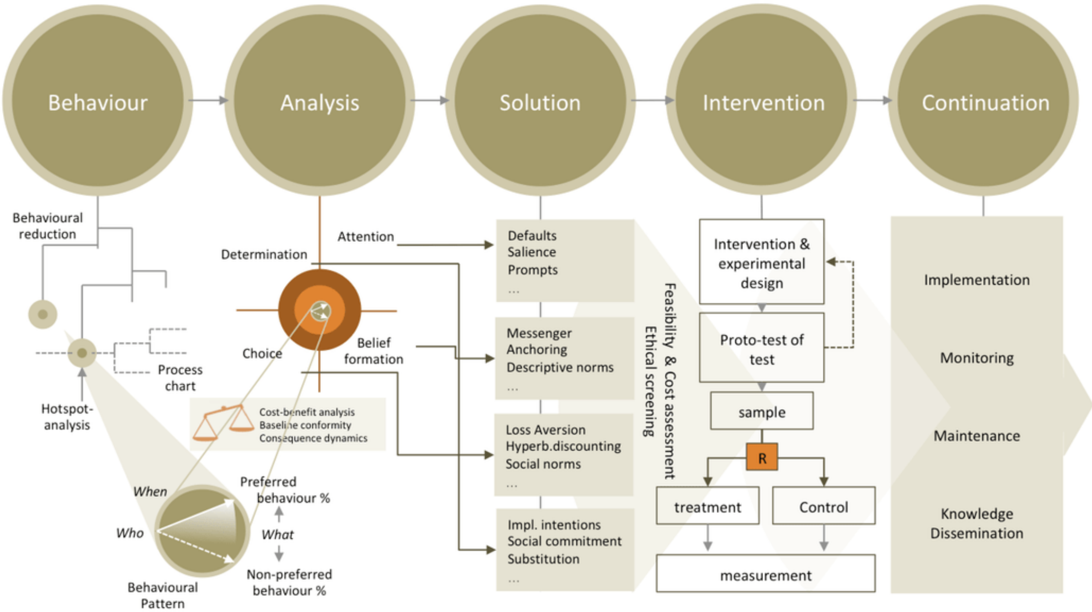

Figure 4 BASIC framework for applying behavioural insights to policy making. Retrieved from (Hansen and Schmidt, 2017)

The above frameworks, as most of the studies in the field of libertarian paternalism reduce to testing '**nudge vs no nudge'** in a real world setting with the use of a RCT. Therefore, the behavioural reduction takes place at the beginning of the study, see *Figure 4*. Another issue of this approach is to ignore external barriers or the possibility to apply behavioural insights to traditional policies, such as mandates and economic incentives.

The previous frameworks provide guidelines for elaborating BI policies under the assumptions of libertarian paternalism and nudging. These, at their turn are based on the behavioural models of the school of thought of Tversky A. and Kahneman D. that treat biases and heuristics as "errors" and deviations from perfect rationality (Kahneman et al., 1982). An alternative school of thought treat heuristics as adaptive mechanisms that can provide "accurate inferences" (Goldstein and Gigerenzer, 2002). More details about behavioural models underlying BI policies will be provided in Chapter 1. The application of these behavioural insights to policy making as alternative to nudges are **boosts** (Grüne-Yanoff et al., 2016, Hertwig, 2017). While nudges are often presented as strategies to exploit the biases, boost policy interventions "*aim to extend the decision-making competences"* of decision makers (Grüne-Yanoff et al., 2016). Boosts present several advantages over nudges, such as disclosure, respect for heterogeneity, diversity of aims of the population and promotion of agency and autonomy in decision making. Nevertheless, the shortcomings of boost approach consist mainly in the necessity of 'basic cognitive abilities' and motivation to improve decision-making skills from the side of general public (Hertwig, 2017). Compared to nudging, boosting is a rather new concept and frameworks regarding its implementation are at an earlier stage, for instance (Hertwig, 2017) proposes six guidelines for policy making in order to guide the choice between nudging and boosting. Because of its early phase of implementation, the nudging approach was preferred in the elaboration of the present research. Yet, the concept of nudging is not considered in the narrow aspect of exclusively making use of the biases, since certain nudges aim to de-bias the decision maker, therefore being similar to boost strategy.

Behaviourally-informed policies - beyond nudging

In the last decade the application of behavioural insights to policy making has increased exponentially (Lunn, 2013, Alain Samson (Ed.), 2018, Lourenço et al., 2016, Dolan et al., 2010), with 196 behavioural insights units/initiatives across the world (Alain Samson (Ed.), 2018). The BI policies were more successful in other fields such as finance and consumer protection than in the field of environment and energy, most of the latter regarded everyday energy use rather than investments in energy renovation (BIT, 2015, BIT, 2016, BIT, 2017, Alain Samson (Ed.), 2017, Alain Samson (Ed.), 2016, Alain Samson (Ed.), 2018). Mainstream policies for the uptake of EE measures still assume a rational consumer in setting up the information campaigns, incentive schemes and information disclosure schemes (mandated energy-use labels) (Allcott and Mullainathan, 2010). This could be one of the possible explanations of the energy-efficiency gap (Ameli and Brandt, 2015, Gillingham and Palmery, 2014, Wilson and Dowlatabadi, 2007).

Therefore on one hand the mainstream policies regarding energy renovation ignore the findings of BE and are based on the assumptions of traditional economic models of rational choice (Allcott and Mullainathan, 2010). On the other hand BI policies, that take into account system 1 thinking have a reductive perspective focusing exclusively on nudging. If nudges are explicit applications of behavioural insights, tested usually with randomized controlled trials (RCTs) (Thaler and Sunstein, 2008), other implicit applications are also possible (Lourenço et al., 2016, Lunn, 2013). For example, certain mandates, such as ban of default pre-ticking in online sales can be informed by evidence from BE (Lunn, 2013). A more detailed explanation of the difference between nudging and BI policies will be provided in Chapters 1, Chapter 3 and Conclusions.

In the context of energy renovation policies, a holistic application of behavioural insights is needed, taking into account both choice architecture and external constraints, the interplay between the behavioural and market failures. Therefore the assumptions and the setup of traditional policies are to be revised in the light of findings from DPMs and BE. Finally, BI policies are not limited to nudging, and can inform the full spectrum of policy measures available such as mandates, information provision and economic incentives.

Goal of the PhD

To investigate a new approach in policies promoting deep energy renovation – BI policies, by questioning the assumptions of traditional economic models of rational choice and taking into account evidence regarding system 1 thinking and bounded rationality. Using the case study of energy renovation, a methodology of elaborating BI policies will be proposed. The full spectrum of policies, from soft to hard paternalism should be considered when elaborating BI policies, addressing both market and behavioural failures.

Aims of the PhD:

- Phase 1
  - Analyse the existing external motivations and obstacles of investing in EE renovation measures (Focus on Flanders).
  - Understand the underlying behavioural mechanisms shaping the investment decisions of private dwellers in EE measures.
- Phase 2
  - Elaborate behaviourally-informed policy, the case study of the Flemish energy performance certificate (EPC).
    - Investigate possible information framings, behavioural insights and the local context (qualitative study).
    - Detect biases and test the efficiency of nudges in avoiding or making use of the biases (quantitative study – laboratory experiments).
  - Elaborate a framework on how to apply behavioural insights to policy making (behaviourally-informed policies).

Research lines and methodology

In terms of methods, a range of qualitative and quantitative methods are used for elaborating BI policy, using the Flemish EPC as a case study. One of the challenges of the present study is to combine two bodies of knowledge – the one of traditional policies regarding energy renovation and the body of knowledge in decision making, based on DPMs. The main focus of the present research being the BI policies (the '**innovative behavioural change'**, see *Figure 5*), these policies cannot be analysed ignoring other internal and external factors of the decision making process. *Figure 5* illustrates how the different lines of the current study relate to the rest of the fields of research relevant to energy renovation policies and BI policies in particular.

Innovative behavioural change provides insights on the influence of system 1 thinking, while other behavioural models investigate the influence of the values, intention and motivation – the **'traditional behavioural change'** (see *Figure 5*). These behavioural models explain energy related behaviour with values, attitude formation, personal norms and self-efficacy (Owens & Driffill, 2008; Perlaviciute & Steg, 2015). Various information campaigns have the purpose to relate energy consumption to environmental issues, and their efforts have increased the general awareness of households about their environmental impact. Yet, a major barrier in the uptake of energy renovation is the intention-action gap or value-action gap (Darnton, 2008; Momsen & Stoerk, 2014), when the awareness does not translate into action. With our focus on 'innovative behavioural change' we do not present nudging as an alternative to information and awareness campaigns, but rather a way to improve their efficiency. Nudges might seem more cost effective policy tools on short term (Benartzi et al., 2017), yet information campaigns are necessary to bring acceptance and their impact is difficult to quantify on long term.

Besides behavioural failures, decisions regarding energy renovation are subject to external factors – from individual factors of the homeowner such as socio-demographics, state of the dwelling, to societal factors such as available technologies, the **'sociological context'** and **'technological context'** of the framework, see *Figure 5*. Even though these are not the central object of study, these external constraints and facilitators cannot be ignored and are part of the literature review and are being considered in the elaboration of the survey regarding type of reasoning (Chapters 1 and 2) and the final framework (Conclusions).

Under this general framework, the following aspects of 'innovative behavioural change' are being analysed with their corresponding methods:

- Way of reasoning behind motivations and barriers for the uptake of EE measures (Part 1)
    - **Literature review** of dual-process models and factors influencing system 1/ system 2 thinking. **Survey (ranking exercise)** with UH employees – regarding motivations and barriers for the uptake of EE renovation measures (Chapter 1).
    - Survey with homeowners interested in renovation – **ranking exercise** and **choice experiment** (Chapter 2)
- Case study of elaborating a BI policy tool – **energy performance certificate (EPC)** of Flanders. The importance of information framing when communicating the energy performance of a dwelling and recommendations (Part 2).
    - **Comparative analysis** of nine European EPCs and **focus group** with experts (Chapter 3). Individuating the possible array of information framings and nudges and adjusting to the local context.
    - **Laboratory experiments** with students for testing various information frames (Chapter 4).
    - **Laboratory experiments** with homeowners to validate previous findings and determine the behavioural mechanism with 2x2 factorial design (Chapter 5).

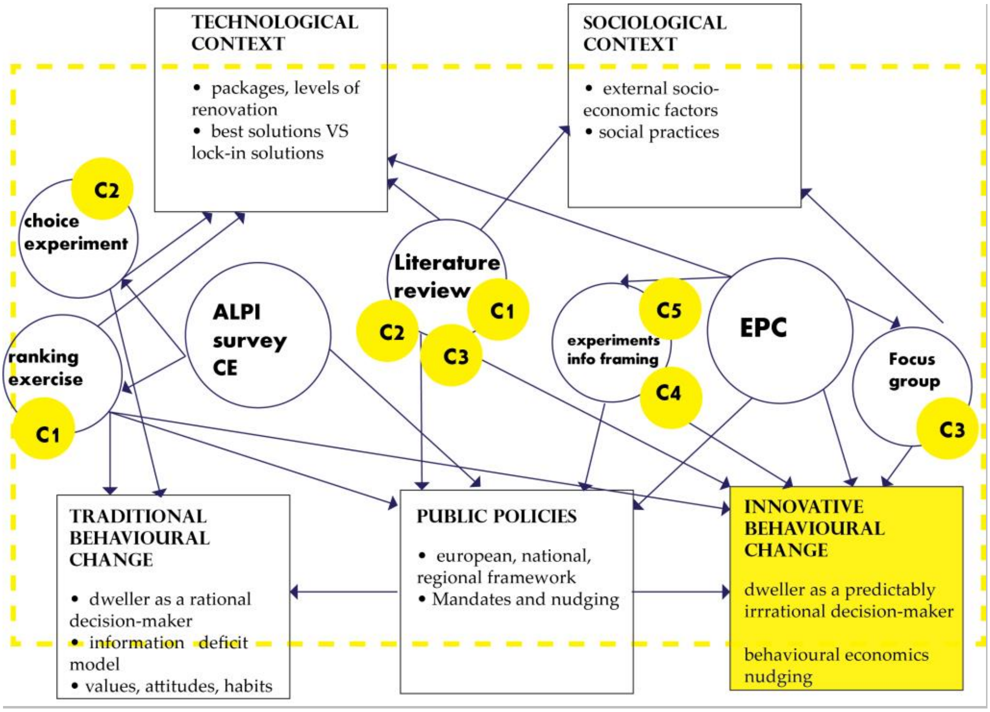

Figure 5 Scheme - PhD research lines and thesis chapters (C1-C5)

- Framework regarding how to communicate energy related information (Conclusions)
  - Literature review
  - Based on laboratory experiments
- Framework regarding how to elaborate behaviourally-informed policies. (Conclusions)
  - Literature review
  - Based on the Flemish EPC case study

The framework proposed in Conclusions aims to address the limitations of a narrow approach of 'nudge vs. no nudge', by proposing a holistic approach of elaborating BI policies.

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Part 1

How do homeowners decide?

The complex world of decision making

Introduction Part 1

BI policies and nudging are based on the assumptions and findings of DPMs and the first part of the thesis provides a more in depth analysis of these behavioural models. The emphasis was on the balance between system 1/ system 2 thinking rather than on biases in isolation, see Chapter 1.

The empirical part of the study explores the implications of the dual thinking to decision-making regarding EE renovation measures. Results of two surveys are presented:

- **Survey (ranking exercise)** with university employees (Chapter 1) that served as a pilot test.
- Survey with homeowners interested in renovation – **ranking exercise** and **choice experiment** (Chapter 2).

The survey aims at further investigating the balance between system 1/ system 2 thinking of dwellers in their decisions to invest. The questions of the ranking exercise regarded five EE renovation measures – wall insulation, EE windows, EE boiler, PV panels and solar water heaters. The arguments of the surveys were based on the most frequently cited reasons from Flemish homeowners in large scale surveys (VEA, 2013, Ceulemans and Verbeeck, 2015) for this reason it was not undertaken a qualitative study previous to the quantitative survey.

The choice experiment had the purpose to assess non-monetary factors such as comfort or CO_2 emissions in monetary terms by translating them in willingness-to-pay. The model chosen was alternative specific with four labelled alternatives: EE windows; roof and wall insulation; geothermal heat pumps and PV panels. Each alternative was described by varying levels of the following characteristics: the degree of visual changes, the thermal comfort obtained, the CO_2 reduction, the investment cost, the hassle during renovation and the source of advice.

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Chapter 1

Dual-process models and their implications to energy renovation[1]

Abstract

Previous policy measures encouraging energy-efficient (EE) renovation rely mostly on the assumption of rational, deliberative decision making. On the other hand, more recent attempts to incorporate findings regarding system 1 thinking to policy have been mostly limited to nudging, based on a mere list of biases. However, BE and nudging are based on the assumptions and findings of dual-process behavioural models (DPMs). Therefore our approach proposes a more in depth analysis of DPMs, especially on the balance between system 1/system 2 thinking rather than on biases in isolation. The first part of the paper presents DPMs relevant to EE renovation. External and internal factors triggering system 1 thinking are detailed, such as need for closure, need for cognition and need for affect.

The second part of the paper explores the implications of the models to decision-making regarding EE renovation measures. Results of a survey (N=248) are presented. The survey aims at further investigating the balance between system 1/ system 2 thinking of dwellers in their decisions to invest. The questions regarded five EE renovation measures – wall insulation, EE windows, EE boiler, PV panels and solar water heaters. The results show that respondents are rather deliberative in their arguments in favour of uptake of the measures, while their arguments against are more balanced. There is a difference in responses

[1] The present chapter is based on the article "*Dual-process models and their implications to energy renovation*", by Taranu Victoria, Verbeeck Griet & Maes Dries. Submitted to the Journal RENEWABLE & SUSTAINABLE ENERGY REVIEWS. Currently it is under revision process.

regarding measures with a higher market penetration (EE windows and EE boiler) compared to more recent measures such as PV panels and solar water heater.

A better understanding of DPMs means taking into account external and internal factors influencing the balance between the two ways of reasoning and can contribute to better behaviourally-informed policies.

Introduction

Understanding the mechanisms behind decision making plays an important role in elaborating policies promoting energy-efficient (EE) renovation. Energy efficiency of the building stock has an important share of the EU target set for 2050 to reduce greenhouse gas emissions by 80 per cent compared to 1990 levels (European Parliament, 2011). The European building stock has a high potential of EE improvement since 64 per cent of the heating systems are inefficient and 44 per cent of the windows are single glazed (European Commission, 2014). Furthermore, Europe is characterized by a 50 per cent rate of owner-occupied dwellings. Many countries including Belgium even have higher rates of over 70 per cent (BPIE, 2011). Therefore it is important to understand the mechanisms behind individual homeowner's decisions to invest, as they can play an important role in elaborating policies promoting energy-efficient (EE) renovation.

The present paper will focus on decision-making aspects of investing in EE renovation measures, including (i) insulation, (ii) energy-efficient HVAC and (iii) production of renewable energy. Appliances and lighting are usually not included in the assessment of the energy performance of residential buildings. We do not consider these decisions in our research because they imply a lower investment cost and a low impact on the overall energy consumption of the residential dwellings. The existing approaches to encourage the uptake of EE renovation can be divided in three main categories, depending on the theoretical assumptions they are based on:

- Neoclassical economics

- Environmental awareness
- Behavioural economics based on dual process models (DPMs)

The first approach, neoclassical economics, is based on the assumption that the householder acts as a *homo economicus,* who pursues utility maximization and is able to choose rationally between the multitude of available EE measures. Nevertheless, this approach has the limitation of regarding individuals as 'computers' with unlimited processing and memory storage abilities, and complete emotional self-control (Thaler and Sunstein, 2008). In case utility maximization is assumed, choices can be investigated by different methods, such as choice modelling for the analysis of drivers behind investments in various types of EE measures (Achtnicht and Madlener, 2014, Jaccard and Dennis, 2006, Rouvinen and Matero, 2013). The purpose of such choice experiments is to assess non-monetary factors such as comfort or CO_2 emissions in monetary terms by translating them in willingness-to-pay. Dwellers are expected to be able to evaluate alternative energy efficient measures that requires understanding of difficult technical information. The utility maximization model states that eventually the wrong estimations will be corrected with experience. This dynamic effect is not valid in this case as each type of EE renovation measure is usually one-off and irreversible, even if the renovation as a whole can be prolonged over time.

The second approach looks at the environmental consciousness of the individuals. Whereas the neoclassical economics approach is based on financial arguments (extrinsic motivation), the environmental consciousness approach targets the individual intrinsic motivation. Energy related behaviour is explained with values, attitude formation, personal norms and self-efficacy (Perlaviciute and Steg, 2015, Owens and Driffill, 2008). Various public and NGO informational campaigns have the purpose to relate energy consumption to environmental issues, and their efforts have increased the general awareness of households about their environmental impact. The vast majority of homeowners acknowledge the importance of energy efficiency. According to the Flemish Energy Agency VEA more than 90 per cent of Flemish consider energy saving as ‘rather’ to ‘very important’ (VEA, 2013). Moreover, these high numbers had an increasing trend in the last two decades, from 87 per cent in 1998 to 93 per cent in 2017. Yet these figures of environmental consciousness resist to translate into action. Large-scale surveys (Bartiaux et al., 2006, Ceulemans and Verbeeck, 2015) document the gap between self-reported intentions and the actual EE measures undertaken. Even though punctual interventions have been undertaken, the number of houses that have a minimum package of insulated roof, double glazing and condensing boiler is still limited and accounts for only 13 per cent of the Flemish dwelling stock (VEA, 2013). It has been shown that it is a general trend in Europe that concerns about climate change do not always translate into environmentally-friendly actions (Wicker and Becken, 2013).

Consequently, filling the intention-action gap with information regarding monetary or environmental benefits proved to have a lower impact than expected (Friege and Chappin, 2014). The two former approaches are based on the assumption that dwellers, whether extrinsically or intrinsically motivated, are exclusively rational in their reasoning. In reality decisions are often suboptimal because individuals are systematically affected by the *“self-control problems, unrealistic optimism, and limited attention”* (Sunstein, 2014). So, the third approach in promoting EE renovation takes into account the human limitations and is based on dual process models (**DPMs)** (Darnton, 2008). According to these behavioural models, information can be processed by two parallel routes: system 1 (type 1 processes) and system 2 (type 2 processes). System 2 thinking is analytic, self-aware, effortful and deliberative, while system 1 thinking is associative, effortless and intuitive (Dolan et al., 2010, Thaler and Sunstein, 2008). The latter is characterized by heuristics and biases that act as fast shortcuts to the cognitive slow thinking (Darnton, 2008).

In the present paper, we will refer to the insights from DPMs as behavioural insights and to policies based on the latter as behaviourally-informed policies. Given the evidence of system 1 thinking, in the recent years there is an increasing interest in applying these behavioural insights to policies (Lourenço et al., 2016, Lunn, 2013, BIT, 2011b, Yoeli et al., 2017). As in other policy fields, in the context of energy renovation up to now the application of behavioural insights was mostly limited to nudging (BIT, 2011b, Momsen and Stoerk, 2014). Nudging consists in "*structuring the choices that people make in order to lead them towards particular outcomes*" (Baldwin, 2014b). Nudges can then favour certain decisions by avoiding or making use of existing biases. Therefore, nudges do not regard exclusively system 1 thinking, but rather the balance between type 1 and type 2 reasoning. Three types of nudges, depending on which thinking it targets, will be explained in more detail in subsection Application of DPMs to policy making - types of nudges. Thus, understanding mechanisms explaining DPMs, including the balance between the types of processing is crucial for elaborating behaviourally-informed policies.

Behavioural insights have been applied to EE renovation policies to a lesser extent compared to other policy fields (BIT, 2016, BIT, 2011b, BIT, 2015, Lourenço et al., 2016, OECD, 2017, Frederiks et al., 2015) and its potential in both nudging and other policy measures is still untapped. The present paper aims to explore the implications of behavioural insights to policies regarding EE renovation beyond a simple list of biases. A better understanding of DPMs can contribute to the elaboration of policies that take into account the balance between system 1/system 2 thinking of the dwellers.

The content of this paper can be divided in two main parts (i) a literature review of DPMs specifically relevant in the area of EE investments, and (ii) the application of DPMs in a survey that explores the implications to EE renovation.

The proposed literature review, with an introduction of dual-process thinking in subsection Dual-process thinking, followed by a classification of DPMs according to the factors that trigger system 1 thinking in subsection Classification of dual-process models, is not exhaustive and it includes only behavioural models that assume dual-process thinking and that are relevant to investments in EE renovation. The decision to invest in EE renovation is a one-off decision, even though it is influenced by everyday energy use. Therefore the overview does not include the DPMs that have habit as the main trigger of the shortcut from the rational thinking. Previous literature reviews gather all behavioural models relevant to residential energy not exclusively limited to DPMs (Wilson and Dowlatabadi, 2007, Darnton, 2008). On the other hand, exhaustive literature reviews about DPMs are more theoretical and are not concerned about its possible implications to policy making (Evans and Frankish, 2013). Previous studies on applying behavioural insights of DPMs to energy renovation (BIT, 2011b, Dolan et al., 2010, Momsen and Stoerk, 2014) were limited to a listing of biases and did not elaborate on the underlying behavioural mechanisms of the models. The present overview elaborates in more depth the balance between two system thinking. Subsection "Balance between system 1/ system 2 thinking – characteristics of the individuals"provides insights on characteristics of the individuals, such as need for closure, need for cognition and need for affect that play a role in the balance.

The second part of the paper focuses on the implications of the behavioural insights to EE renovation decisions, and builds a survey to investigate this in practice. Firstly, a theoretical framework of three types of nudges is presented in subsection Application of DPMs to policy making - types of nudges. This classification proposed by (Baldwin, 2014b) is based on the type of thinking the nudge is addressing. Therefore the previous literature review regarding DPMs and the balance between types of processing is of relevance. Secondly, section Survey: system 1/ system 2 thinking in decisions regarding energy-efficient renovation details the method of the empirical part, i.e. the behavioural insights that served for elaborating the questionnaire and the main results of the online survey with Flemish dwellers. Unlike previous studies that focus on biases in isolation, the aim of the study is to investigate the reasoning behind and the balance between system 1/ System 2 thinking. The survey explores the way of reasoning in investment decisions regarding five EE renovation measures - wall insulation, EE windows, EE boiler, PV panels, solar water heater. In conclusion, implications for public policies are proposed based on the findings of the DPMs overview and the survey.

Dual-process models and energy renovation

Dual-process thinking

Concurrent system 1/system 2 thinking is taken into account by the third approach of promoting EE renovation, based on behavioural insights of the DPMs. *Figure 6* illustrates two ways of thinking: type 2 processes (deliberative, slow) and the type 1 processing that runs as a shortcut to the former. Many behavioural models use the term system1/ system 2, that was coined by Stanovich K.E. in 1999 (Stanovich and West, 2000). Nevertheless, Stanovich K.E. himself in a later publication agrees that type 1/ type 2 processes is more appropriate since these are 'virtual systems' with different ways of processing the information (Evans and Frankish, 2013). Type 2 is controlled, analytic and self-aware, while type 1 is automatic and heuristic. Besides these main traits, *Table 1* presents other characteristics that are descriptive, but not always necessary, depending on the behavioural model. Former theoretical approaches in policy making assume a prevailing type 2 thinking. DPMs, on the other hand, take into account that often humans tend to escape this deliberative processing of the information with the use of shortcuts called heuristics and biases.

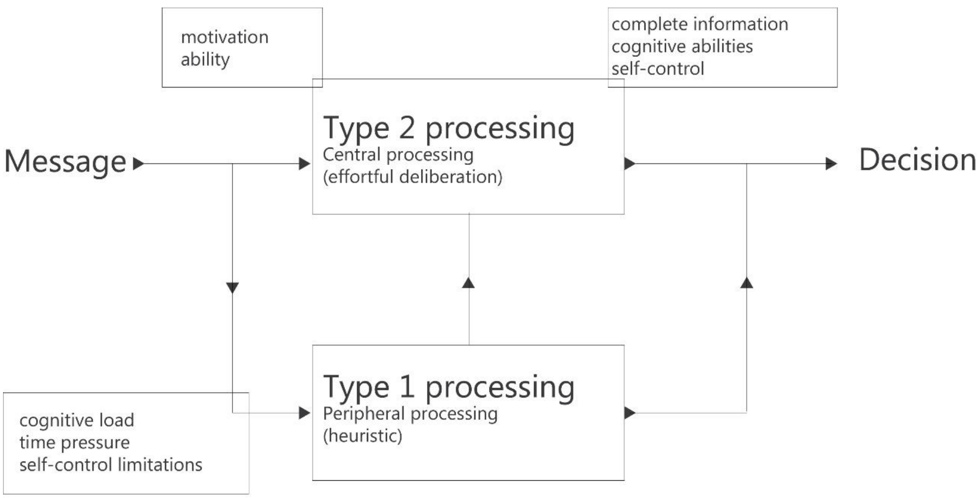

Figure 6 Scheme dual-process thinking

Table 1 Properties of Type 1 and type 2 processes according to various DPMs. Adapted from (Evans and Frankish, 2013, Stanovich and West, 2000, Dolan et al., 2010, Evans, 2008)

Type 1 processes	***Type 2 processes***
Heuristic	*Analytic*
Intuitive	*Deliberative*
Associative	*Rule based*
Automatic	*Controlled*
Relatively fast	*Relatively slow*
Low effort	*High effort*
Adaptive unconscious	*Conscious, self-aware*
Evolutionary old	*Evolutionary recent*
Shared with animals	*Distinctively human*
Nonverbal	*Linked to language*
Implicit, tacit knowledge	*Explicit knowledge*
Contextualized	*Abstract*
Impulsive	*Reflective*
Default process	*Inhibitory*
Emotional	*Deductive*
Experiential	*Rational*
Holistic	*Analytic*
Stereotypical	*Egalitarian*
Independent of general intelligence	*Linked to general intelligence*
Independent of working memory	*Limited by working memory capacity*

Biases might increase the efficiency of decision making, being less effortful (Finucane et al., 2000, Simon, 1955). Heuristic thinking is important in small decisions of everyday life. Yet, these biases might persist in important decisions regarding renovation, without people being aware of it. DPMs assume that humans switch continuously between these two pathways when processing information. *Figure 6* represents the duality and parallel thinking. Some behavioural models, such as the one proposed by Evans St. B. T. assume that type 1 thinking might precede deliberative thinking (Evans and Frankish, 2013). The model of Evans St. B. T. will be discussed in more detail in the following subsection, alongside other DPMs that are classified according to the main factors affecting the balance between type 1/ type 2 thinking.

Classification of dual-process models

Starting from 1950s on, research in the field of psychology provides empirical evidence of the dual processing of information as a reaction against the ever increasing belief in exclusively rational decision making in economic models. An overview of the existing DPMs is given in *Table 2*. The proposed literature review is not exhaustive and it includes only behavioural models that assume dual-process thinking relevant to investments in EE renovation[2]. Since decisions to invest in energy-efficiency are one-off decisions, the present overview does not include the DPMs that have habit as the shortcut to deliberative thinking.

Certain DPMs focus on decisions taken under uncertainty, time pressure and cognitive load, when people tend to avoid the difficult cognitive deliberation with the use of a fast, intuitive shortcut (Tversky and Kahneman, 1974, Tversky and Kahneman, 1973). This principle is the theoretical basis of behavioural economics, with Simon's model Bounded Rationality (Simon); Tversky and Kahneman´s Judgment Heuristic (Kahneman et al., 1982) and Prospect Theory (Kahneman and Tversky, 1979). These models focus exclusively on the cognitive errors that are deviations from the normative models such as Utility Theory and assume the existence of two parallel systems.

One of the first theorizations of heuristic thinking in the context of economic decisions was Bounded Rationality (Simon) back in the 50's. Simon H.A. challenged the assumption of the neoclassical economics according to which the

[2] For a more complete overview of DPMs regardless of the context, see EVANS, J. S. B. T. & FRANKISH, K. 2013. *In two minds: dual processes and beyond,* Oxford, Oxford University Press, EVANS, J. S. B. T. 2008. Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. *Annual Review of Psychology,* 59**,** 255-278..

consumers are able to maximize utility in a perfectly rational way (Simon, Blasch et al., 2016). According to Simon H.A., the theoretical models of neoclassical economics predict how people **should** behave, not how they **actually** behave. Instead, he proposes a model that considers the human limitations, such as the cognitive limitation to store and process the information, as well as self-control limitations to "*adjudicate among many competing wants*"(Simon, 2000a). The model is framed from the point of view of human limitations, leaving aside the choice environment. It is advocated for the application of insights and methods from psychology in the construction of economic theories and operationalization (Simon, 2000a).

Bounded rationality hinted towards the existence of simplifications that the individual utilizes "*in order to bring the model within the range of its computing capacities*", later theorized as biases and heuristics. Biases are "*errors to maximize utility*" (Rabin, 1998). The interference of biases in economic decisions were empirically endorsed by the findings of Tversky A. and Kahneman D. **Judgment Heuristic** (Kahneman et al., 1982) documents evidence from experiments regarding systematic errors in assessing probability. The main biases and their grouping in three heuristics – **availability**, **representativeness** and **anchoring** are explained in more detail in subsection System 1 reasoning.

Another theorization of Tversky A. and Kahneman D. regarding the deviation from the rational choice theory is the Prospect Theory. If the Expected Utility Theory assumes that consumers assess final assets, the **Prospect Theory** stipulates that consumers take decisions in terms of gains and losses (Kahneman and Tversky, 1979). Most of the time decision making implies the assessment of likelihood of uncertain events – their probability (Tversky and Kahneman, 1974). Tversky A. and Kahneman D. provide evidence of a systematic errors of overweighting or underweighting probabilities, depending on how the information is framed – in terms of losses or gains. People are loss-averse, they usually take more risks in order to avoid losses. Another aspect is the isolation effect – when people assess the probability of two alternative events, the common information would be ignored. Therefore, the decisions differ depending on how the information is presented.

The school of thought of Tversky A. and Kahneman D. regards cognitive biases and heuristics as 'errors' of rational judgment. The school of thought of Gigerenzer. G et al. disagrees with this approach because by rational judgment are implied statistical models, such as Bayes' rule, ANOVA, etc. (Goldstein and Gigerenzer, 2002). According to them instead, heuristics are psychological mechanisms that resulted from adaptation of organisms. They propose the model of 'fast and frugal heuristics' that are 'efficient cognitive processes' (Gigerenzer and Gaissmaier, 2011) that can yield good outcomes and challenge the assumption of the trade-off between speed and accuracy in decision making (Todd and Gigerenzer, 2000).

The second group of DPMs summarized in *Table 2* include System 1/ System 2 of Stanovich and West (Stanovich and West, 2000) and type 1/ type 2 processes of Evans (Evans, 2006). These decision-making models do not focus only on deviations from assumptions of Utility Theory but provide more insights on dual process thinking. According to **System 1/ System 2** model of Stanovich K.E. and West R. F. deviations from rational choices can be explained by four reasons – "*performance errors, computations limitations, wrong norm being applied by the experimenter and different construal of the task by the subject*" (Stanovich and West, 2000). As the previous DPMs, this model focuses exclusively on the cognitive limitations of decision making and systematic errors. Yet, Stanovich K.E. and West R. F. are interested in individual differences of the subjects with regard to these four explanations of the gap. Besides, the authors offer a literature review of how system 1 and system 2 are described by various previous research studies. System 1 is automatic, heuristic, associative, contextualized, socialized, personalized and uses implicit inferences and tacit thought process. System 2 is controlled, analytic, rule-based, decontextualized, asocial, depersonalized and uses explicit learning and an explicit thought process (Stanovich and West, 2000).

If the previous DPMs use the terminology of two systems, Evans J. St. B. T. pleads for the terminology of **type 1 and type 2 processes**, as "*virtual systems that emerge from interaction of a number of modular cognitive systems*"(Evans and Frankish, 2013). Therefore type 1 and types 2 processes are not related to physically different parts of the brain, but rather different ways of reasoning, the main differences being operational such as use of working memory. Another advancement from previous DPMs is the assumption of '*preattentive processes*'– type 1 processes, that occur before analytic processes (Evans, 2006, Evans and Frankish, 2013). Another category of type 1 processes, similar to the previous DPMs, are '*autonomous processes*', that run in parallel and compete with type 2 processes and can function as a shortcut to behaviour.

Another perspective on dual process thinking is theorized by Petty R. E. and Cacioppo J.T. with **Elaboration Likelihood Model** (Petty and Cacioppo, 1984). According to the authors, people process the information neither in a completely thoughtful way (System 2), nor in in a mindless way (System 1) (Petty and Cacioppo, 1984). The latter implies that decisions are made based on positive or negative cues. The balance between the two ways of thinking depends on a range of individual and situational factors, most importantly on the *motivation* to think. If the information is relevant for the individual, he is more likely to process the information in a deliberative way (high elaboration likelihood). In their experimental studies, Petty R. E. and Cacioppo J.T. investigated whether the source of the information is relevant in persuasion. The findings show that source of the information, experts or celebrities, is relevant only in the case of system 1 thinking (low elaboration likelihood). In the case of deliberative thinking (high elaboration likelihood), the source of information is irrelevant, while the arguments play a more important role.

If most of the DPMs consider the cognitive limitations of decision making, the following models emphasize the influence of emotions. According to Slovic's **Affect Heuristic Theory**, individuals use 'affect heuristic' as a shortcut to analytic thinking when assessing risk and benefits (Finucane et al., 2000). Slovic provides evidence that certain decisions are based on instant positive or negative affects while motivations and justification of these decisions is provided only afterwards.

Table 2 Classification of the dual-process models. Adapted from (Darnton, 2008, Evans and Frankish, 2013)

Main factors of the balance between type 1/ type 2 processing	Model, theory	Authors	Year	Reference
Uncertainty, time pressure, heavy cognitive load	Bounded rationality	Simon H. A.	1955	(Simon, 1955)
	Judgment heuristic	Tversky A. Kahneman D.	1974	(Tversky and Kahneman, 1974)
	Prospect Theory	Tversky A. Kahneman D.	1979	(Kahneman and Tversky, 1979)
Individual and situational factors	Fast and frugal heuristics	Gigerenzer G. Todd P.M. Goldstein D.G.	1999 2002	(Goldstein and Gigerenzer, 2002, Todd and Gigerenzer, 2000, Stanovich and West, 2000)
	System 1/ System 2	Stanovich K.E. West R.F.	2000	(Stanovich and West, 2000)
	Type 1/ type 2 processes	Evans J. St. B.T.	2006	(Evans, 2006)
	Elaboration Likelihood Model	Petty R.E. Cacioppo J.T.	1984	(Petty and Cacioppo, 1984)
Emotions	Affect heuristic	Slovic P.	2000	(Finucane et al., 2000)
	Risk as feelings model	Loewenstein G.F.	2001	(Loewenstein et al., 2001)

Once again, affect is more likely to work as a heuristic when the information is complex and the mental resources are limited. In these instances, individuals will use the fast affective impression as a shortcut to processing the information in a deliberative way. The implications of affect heuristic to decisions regarding EE renovation will be detailed in subsection System 1 reasoning. Similarly, **Risk as Feelings Model** of Loewenstein G. F. (Loewenstein et al., 2001) stipulates a direct path between emotion and behaviour. The characteristics of the individuals that concern engaging in emotions – 'need for affect' will be explained in subsection Need for affect.

To conclude, *Table 1* summarizes the main differences between type 1/ type 2 processes according to various DPMs including many models that are not mentioned in this subsection (Evans and Frankish, 2013, Stanovich and West, 2000, Dolan et al., 2010, Evans, 2008). Not all properties are compulsory for the labelling of the type of thinking, some being descriptive properties, depending on the behavioural model.

Balance between system 1/ system 2 thinking – characteristics of the individuals

The main feature of DPMs is the concurrent possibility of processing certain information in a slow, deliberative way (type 2 processing) or in a fast, intuitive, heuristic way (type 1 processing). Understanding the factors influencing this delicate balance is significant for policy making. When considering alternative EE renovation measures, homeowners usually face difficult technical information. Besides the complexity of the information and the variety of possible solutions, the problem of uncertainty persists. There is little consensus on which option is more suitable or cost effective for a particular dwelling, since the sustainability of a technology in its complete life-cycle is strongly context dependent. For example the efficiency of solar and wind technologies depend on the orientation and the dwelling, the micro-climate conditions, or the quality of installation. The sustainability of biomass technologies depends on the availability and origin of the biomass, etc. Under these circumstances the effortful analysis of the information might be avoided with the use of system 1 thinking.

Besides the difficulty of the information and other external contextual factors, the balance between the type of reasoning depends on the individual's characteristics. Parameters that measure the availability to engage or avoid deliberative thinking are need for closure, need for cognition and need for affect.

Need for closure

Need for closure is defined by Kruglanski A. as "*desire for a firm answer to a question, any firm answer as compared to confusion or ambiguity* (Mannetti et al., 2007). In their urge for clarity, people with high level of need for closure are more likely to use the bias as a shortcut in detriment to deliberative thinking. Nudges that use biases and heuristics towards a predictable outcome would be more effective for individuals with high need for closure. Yet, even for individuals with high need for closure, deliberative thinking could be improved, for instance by simplifying complex messages. Besides being inherent characteristics of the individuals, need for closure is influenced by external and situational factors such as time pressure, boredom, fatigue, noise, et. It can be measured with a 42 item scale translated in various languages (Mannetti et al., 2007).

Need for cognition

Contrary to the need for closure, the 'need for cognition' refers to an individual's tendency to "*engage in and enjoy effortful cognitive endeavors*" (Cacioppo et al., 1984). The higher the need for cognition, the higher is the probability that the individual will engage in deliberative thinking and process difficult information. Therefore nudges that address type 2 reasoning by avoiding the bias, would be more effective for individuals with high need for cognition. On the contrary, individuals with low need for cognition are more prone to avoid difficult cognitive processing and are more likely to be influenced by nudges that involve system 1 thinking. This can be assessed with a need for cognition scale with a standard version of 34 items, whereas the shorter version is of 18 items (Cacioppo et al., 1984, Haugtvedt et al., 1992). Need for cognition is correlated with "*automaticity* *in social judgments*" (Evans and Frankish, 2013), therefore individuals with a low need for cognition might be more prone to social norm bias and stereotyping.

Need for affect

Difficult information is not the only trigger of system 1 thinking, besides cognitive biases there is also an affect heuristic. The balance between a cognitive and an emotional evaluation depends on the information presented, as well on the individual's "*motivation to approach or avoid emotion-inducing situations*", also called 'need for affect' (Maio and Esses, 2001). The dwelling is a home, not merely a physical house. The existing state of the dwelling is associated with warmth, family and pleasant memories. These emotional bounds can be an important impediment for assessing rationally the economic benefits of the EE renovation. For this reason messages or images promoting EE renovation should associate nZEB with warmth, cosiness and well-being, and not only with convenience and technology. Need for affect can be measured with a 26 item scale, out of which 13 items assess the motivation to approach emotions and 13 items assess the motivation to avoid emotions (Maio and Esses, 2001).

Need for affect and need for closure are negatively and significantly correlated (Maio and Esses, 2001). Surprisingly, the correlation between need for affect and need for cognition is significant and positive, therefore people that are more willing to engage in cognitive effort, are also more willing to engage in emotional experiences (Maio and Esses, 2001). The implications of these characteristics of the individuals in relation to the three types of nudges will be analysed in the following subsection.

Application of DPMs to policy making - types of nudges

An example of explicit application of behavioural insights to policies is nudging, that is only one of the possible applications. Nudges are deliberate changes in the presentation of information or choice in order to influence decisions towards a known outcome. The term **nudge** gathers "*any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any* *options or significantly changing their economic incentives."* (Thaler and Sunstein, 2008). But not any change in the choice architecture is a nudge, for example information provision that affects a perfectly rational *homo economicus*. In order to qualify as a nudge, it has to concern system 1 thinking or the balance between type 1/ type 2 thinking. We propose the following definition of nudge – "**a slight change in choice architecture that affects system 1 thinking or the balance between the two systems and steers behaviour towards a predictable direction".**

Baldwin R. (Baldwin, 2014a) classifies the nudges depending on the way of reasoning, since nudges are designed to make use of these switches. Three types of nudges can be distinguished, as illustrated in *Table 3*.

According to Baldwin R., the 'First Degree nudge' has the purpose to enhance reflective decision making and avoid an existing bias (Baldwin, 2014a). An example of this type of nudge is simplified disclosure, for example introduced in the US in 2009 for financial products (Lunn, 2013). Overload of difficult to process information might contribute to its heuristic interpretation. Simplified disclosure has been tested in the context of complex financial products, such as credits and loans (Bubb and Pildes, 2014, Lunn, 2015). Besides simplified disclosure, salience (Hallsworth et al., 2014) of the main information aims to *debias* decision makers (Lunn, 2013).

Table 3 Classification of nudges. Adapted from Baldwin R. (Baldwin, 2014a)

	First Degree Nudge	*Second Degree Nudge*	*Third Degree Nudge*
Purpose	*Avoid an existing bias*	*Use an existing bias towards a predictable outcome*	*Induce a new bias*
Type 1 processing/ type 2 processing	*Type1* ⬇ *Type 2*	*Type 1* 	*Type 2* ⬇ *Type 1*
Example	*Simplified disclosure*	*Opt-out default*	*Image association*

The ‘Second’ and ‘Third Degree’ nudges use an existing or a newly induced bias towards a predictable outcome, addressing type 1 thinking (Baldwin, 2014a). An example of the former is the default nudge, that exploits the tendency of the people to follow the flow of pre-set options (Hallsworth et al., 2014, Dolan et al., 2010, Lourenço et al., 2016, Elisabeth et al., 2016). The latter induces a new bias, for example a negative image association with smoking (Baldwin, 2014a). According to Sunstein C. (Sunstein, 2016), ‘First Degree’ nudges are system 2 thinking or *educative* nudges, and ‘Second’ and ‘Third Degree’ nudge are system 1 thinking or *noneducative* nudges. Educative in this context means that the nudge is intended to reframe the information in order to get a rational response. This is in contrast to the other two types of nudges, that are intended to provoke a system 1 processing of information.

Yet this alternative classification of nudges is more ambiguous and leaves space to more interpretations. A nudge can only work when assuming the duality in processing information. In theory, the presence or absence of nudges should not affect perfectly rational people. Not any information provision is a nudge, its presence or absence should not affect rational people. Nudges always involve type 1 processing of information. Therefore an improved understanding of the balance between the two ways of reasoning is essential for a correct elaboration and implementation of nudges.

Nudges belong to the rationale of libertarian paternalism, that implies “*careful design of collective structures of choice, in a range of different policy areas, which facilitate more effective decision-making while enhancing personal freedom*” (Jones et al., 2011). Indeed, preserving the freedom of choice is only one of the possible applications of DPMs to policies. Implicit application of behavioural insights can translate into traditional policy measures such as mandates or mechanisms of implementing financial incentives. Therefore, behaviourally informed policies based on insights of the DPMs do not limit to libertarian paternalism (Lunn, 2013, Lourenço et al., 2016).

Survey: system 1/ system 2 thinking in decisions regarding energy-efficient renovation

Survey method

In the previous sections behavioural models that regard duality of thinking were summarised. The balance between the systems is relevant to elaborating BI policies such as nudges. At the same time, it is relevant to explore the implications of these theoretical insights to the particular policy context of energy renovation. We investigate the balance between system 1/ system 2 thinking when respondents analyse renovation measures for increasing the energy efficiency of their house. To this effect, a survey was designed. Our hypothesis is that arguments in favour are mostly deliberative (D+) and the ones against are mostly heuristic (H-).

- Arguments in favour mostly deliberative $\Sigma(D+) > \Sigma(H+)$
- Arguments against mostly heuristic $\Sigma(H-) > \Sigma(D-)$

Clues supporting these hypotheses resulted from a focus group on behavioural insights regarding EE renovation organized in April 2015 with municipal officials in the context of Werfgoed Living Lab, a research project in which methods to mobilize dwellers for EE renovation were tested in practice in collaboration with municipalities (Verbeeck and Boesmans, 2018). Among arguments in favour of EE renovation were listed "to reduce the footprint" (ecological values, beliefs), "house increases in value" (expected utility); whilst among arguments against the EE renovation were listed "a lot of cluster, noise, dust" (affect heuristic), "I like how my house looks now" (endowment effect, status quo bias). There is a certain subjectivity in categorizing the arguments into deliberative and heuristic, yet the classification was undertaken during the design phase of the study, prior to data collection. The categorisation took place not in terms of the reason prevailing, but rather in the way it is framed. If the pattern of the hypotheses is confirmed, this information is useful for any type of communication related to the adoption of EE renovation measures. For example "*It costs too much*" corresponds to a deliberative argument while *"Are much cheaper than PV panels"* to anchoring heuristic, see *Table 4*.

The questionnaire is designed to separate negative arguments (barriers) from positive arguments (motivations). The survey regards five individual EE renovation measures: wall insulation, EE windows, EE boiler, solar panels and solar water heater. On each measure two questions were presented to respondents, with arguments in favour and against the uptake. An example of this set is illustrated in *Table 4*.

Table 4 Example of questionnaire item with the explanation of the behavioural models (not visible to respondents) 1.1 Negative arguments in favour of placing the measure 1.2 Positive arguments

1.1	*I would install solar water heater because…*		*Type*	*Behavioural Model/ Insight*
	A	*It is good for environment to save energy*	*D+*	*Value-belief-norm theory*
	B	*Are much cheaper than PV panels*	*H+*	*Anchoring*
	C	*All my neighbours installed*	*H+*	*Social norm*
	D	*Are cost effective*	*D+*	*Expected utility*

1.2	*I would not install solar water heater because…*		*Type*	*Behavioural Model/ Insight*
	A	*It is too difficult to install: dirt, mess*	*H-*	*Affect heuristic*
	B	*It costs too much*	*D-*	*Expected utility*
	C	*I do not know much about its advantages and disadvantages*	*D-*	*Information deficit*
	D	*A friend has a bad experience installing/ using solar heaters*	*H-*	*Availability heuristic*

The starting position of the respondents is different if they already installed the specific EE renovation measure in their house. So the questionnaire started by asking the actual situation of the house. If the measure is already taken up, the questions are phrased as: " *The main reasons for placing wall insulation were...*", and "*Even if I decided to install wall insulation, these were the reasons that made me hesitate...*". If the measure has not been taken up, the questions ask why the respondents would or would not adopt the measure. In each case, the set-up clearly distinguishes positive from negative arguments. The combination with the knowledge on the actual situation of the house, also indicates which arguments finally got the upper hand.

The arguments are based on the most frequently cited reasons from Flemish homeowners in large scale surveys (VEA, 2013, Ceulemans and Verbeeck, 2015). Each question includes four options, with two deliberative arguments (based on Value-belief-norm, Expected Utility theories) and two heuristic arguments (based on biases such as anchoring, availability, affect heuristic, social norm), see *Table 4*. The description of the behavioural models are not visible to respondents. The respondents rank the four options of the question from most appropriate to least appropriate. For our analysis we have assigned a score to this ranking from 4 to 1. For each respondent we summed up the score of the two rational options and the two heuristic ones.

System 1 reasoning

As mentioned in the previous sections, Tversky A. and Kahneman D. regards cognitive biases and heuristics as '*errors*' of rational judgment (Tversky and Kahneman, 1974), while Gigerenzer. G proposes a model of '*fast and frugal heuristics*' that are '*efficient cognitive processes*' that can yield good outcomes (Todd and Gigerenzer, 2000) (Gigerenzer and Gaissmaier, 2011). In the present study the outcomes hardly be judged as correct or wrong because they depend on the personal circumstances of the homeowners or the changing conditions of the market of EE measures. Therefore the outcome of the judgment is not of interest, but rather the way of reasoning behind. This subsection explains in more detail the biases and heuristics that were implied and included in the elaboration of the survey, see *Table 4*.

Availability heuristic: the probability of an event or the frequency of an object is assessed by the ease with which it can be recalled (Kahneman et al., 1982). If the event is present in the memory, the bias is due to *retrievability* (Tversky and Kahneman, 1974). The choice of a certain EE renovation measure could be based on its familiarity (already known information or singular cases from friends) or on its salience (PV panels have high visual impact, certain technologies have more coverage in media, etc.).

Adjustment and anchoring: in order to estimate a certain value, people start from an initial value called *anchor* and try to adjust it accordingly. It could be a way of assessing subjective utility if not for the heuristic aspect according to which *"different starting points yield different estimates"* (Kahneman et al., 1982). This is one of the reasons why framing of the message is highly influential.

Satisfice bias: people aim for a satisfactory result, rather than an optimal result (Brafman and Brafman, 2009). When confronted with too many options and too complex information, often people rush for the *'good enough'* and avoid seeking *'the best'* option (Frederiks et al., 2015). This might be the case for the choices among EE renovation measures. People with a high level of need for closure are more likely to incline for the first *satisficing'* option that is encountered. Moreover, satisfice bias might be related to **status quo bias** if the existing state of the dwelling is perceived as 'good enough' and, as a consequence, EE renovation is discarded altogether.

Social norms: the decisions are heavily influenced by others' opinions or others' decisions (Frederiks et al., 2015, Brafman and Brafman, 2009, BIT, 2011a). Social norms might explain the choice for under optimal, lock-in technologies. These solutions give the confirmation, recognition that these are the best solutions ("*there must be a reason why everybody chooses it*"). *Descriptive* social norms represent the behaviour of the majority for purpose of comparison (similar to anchoring), while *injunctive* social norms, represent the approved behaviour (Darnton, 2008).

Time discounting: the benefits or the costs in the present outweigh the ones in the future (BIT, 2011a, Elisabeth et al., 2016). Time acts as a dimmer on assessing the future savings on the utility bills, while the investment cost in the EE measure is more salient. The consumer fails to rationally assess the net present value of the investment in energy efficiency in an array of contexts, including labelling of appliances and cars (Lunn, 2013). The opposite effect could work for a loan for purchasing a house: the benefits are in the present, while the costs are underestimated because will occur in the future.

Affect heuristic Besides cognitive biases, people are affected by emotions – affect heuristic (Finucane et al., 2000). The influence of the emotions might be underestimated because people often post-rationalize with arguments the decision already made based on emotions. According to R.B. Zajonc "*We don't see "A house": We see a handsome house, an ugly house. … We choose houses we find attractive and then justify these choices by various reasons*."(Zajonc, 1980). Besides interfering with purchase decisions, it might play a role in the decisions to renovate. Renovation often associates with dirt, mess, noise and these negative affects could precede and influence the deliberative process of weighting the costs and benefits.

Results

The questionnaire was distributed by email to 1983 employees of Hasselt University in December 2015. The response rate was of 15.3 per cent and out of 303 responses received, 248 were complete and usable. The mean age of the sample is 36.4 years (minimum 20 and maximum 79) and the percentage of women is 54.4 per cent. Respondents have a higher level of education than average. Regarding the dwelling type and the ownership, the figures of the sample are similar to the Flemish figures, with 77.8 per cent of houses compared to apartments and 76.2 per cent of ownership (slightly higher than 69.6 per cent of houses and 70.5 per cent ownership in Flanders (Ceulemans and Verbeeck, 2015)).

For each measure the responses of the homeowners who installed it were analysed separately from the ones who did not and the renters (Wilcoxon signed-rank test, significant results at $p<0.05$). The former group of responses consists of stated preferences over revealed choices of installing the measure. That means they could overcome the external barriers and the internal arguments against the uptake. The latter group did not install the measure either due to external barriers such as being a renter or because their motivations did not prevail over arguments against placing the measure.

Table 5 Uptake of the energy efficient measures among the surveyed dwellers compared to Flemish data

	Sample (2015 data)	***Flanders (2013 data Large Housing survey (Ceulemans and Verbeeck, 2015))***
Wall insulation	*39.9%*	*44.8%*
EE windows	*56.9%*	*76.8%*
EE boiler	*45.6%*	*58.1%*
PV panels	*18.1%*	*7.6%*
Solar water heater	*10.5%*	*1.7%*

In terms of market penetration, the measures presented in *Table 5* can be clustered into:

- High (EE windows and EE boiler)
- Medium (wall insulation)
- Low (PV panels and solar water heater)

The sample has a slightly lower uptake of the most widespread measures in the market (EE windows, EE boiler and wall insulation) compared to the Flemish population, while they are early adopters of PV panels (18.1 per cent compared to 7.6 per cent) and solar water heaters (10.5 per cent compared to 1.7 per cent), see *Table 5*.

*Table 6 Homeowners who installed the measure. Results of the Wilcoxon signed-rank tests. *** p-value <0.001, ** p-value < 0.01, * p-value< 0.05.*

Cohen's classification of effect sizes 0.1 (small effect), 0.3 (moderate effect) and 0.5 (large effect).

	Positive Deliberative-Heuristic			***Negative Deliberative -Heuristic***		
	p-value	*Effect size*	*Outcome*	*p-value*	*Effect size*	*Outcome*
Wall insulation	*<0.001****	*Large 0.54*	*Σ(D+)> Σ(H+)*	*0.0001****	*Moderate 0.38*	*Σ(D-)> Σ(H-)*
EE windows	*<0.001****	*Large 0.80*	*Σ(D+)> Σ(H+)*	*0.3242*	*Small 0.083*	*Σ(D-)= Σ(H-)*
EE boiler	*<0.001****	*Large 0.82*	*Σ(D+)> Σ(H+)*	*0.5935*	*Small 0.05*	*Σ(D-)= Σ(H-)*
PV panels	*<0.001****	*Large 0.83*	*Σ(D+)> Σ(H+)*	*0.00719***	*Moderate 0.4*	*Σ(D-)> Σ(H-)*
Solar water heater	*<0.001****	*Large 0.77*	*Σ(D+)> Σ(H+)*	*<0.001****	*Large 0.77*	*Σ(D-)> Σ(H-)*

Each question with positive and negative arguments for each EE measure included four options - two options qualified as deliberative and two as heuristic. The points assigned to each ranking were summed up, the arguments in favour of installing a certain measure being Σ(D+) and Σ(H+), while the arguments against Σ(D-) and Σ(H-). Wilcoxon signed-rank tests were run to verify whether the difference between the two sums of the points assigned to the ranking of deliberative and heuristic arguments Σ(D+)- Σ(H+) and Σ(D-)- Σ(H-) is significantly different from 0. Wilcoxon signed-rank test is a non-parametric test and it was chosen because variables did not meet the assumption of normal distribution of the parametric tests. The statistical analysis was computed using RStudio version (2016). *Table 6* and *Table 7* summarize the results.

*Table 7 Homeowners who did not install the measure and renters. Results of the Wilcoxon signed-rank tests. *** p-value <0.001, ** p-value < 0.01, * p-value< 0.05.*
Cohen's classification of effect sizes 0.1 (small effect), 0.3 (moderate effect) and 0.5 (large effect).

	Positive Rational-Heuristic			***Negative Rational-Heuristic***		
	p-value	*Effect size*	*Outcome*	*p-value*	*Effect size*	*Outcome*
Wall insulation	*<0.001****	*Large 1.04*	*Σ(D+)> Σ(H+)*	*<0.001****	*Large 0.68*	*Σ(D-)> Σ(H-)*
EE windows	*<0.001****	*Large 0.57*	*Σ(D+)> Σ(H+)*	*0.5134*	*Small 0.09*	*Σ(D-)= Σ(H-)*
EE boiler	*<0.001****	*Large 0.92*	*Σ(D+)> Σ(H+)*	*0.6823*	*Small 0.047*	*Σ(D-)= Σ(H-)*
PV panels	*<0.001****	*Large 1.18*	*Σ(D+)> Σ(H+)*	*<0.001****	*Large 0.92*	*Σ(D-)> Σ(H-)*
Solar water heater	*<0.001****	*Moderate 0.31*	*Σ(D+)> Σ(H+)*	*<0.001****	*Large 0.68*	*Σ(D-)> Σ(H-)*

For both categories of dwellers the initial hypothesis was confirmed for positive arguments, where deliberative thinking prevails, Σ(D+)> Σ(H+), see *Table 6*. For negative arguments the results vary according to the measure. For wall insulation and PV panels rational arguments still prevail Σ(H-)< Σ(D-), even if this is with a moderate effect size compared to large effect size of positive arguments. For EE windows and boilers the rational and heuristic thinking are balanced Σ(H-)= Σ(D-). It is important to underline that the latter measures are the most popular with respectively 56.9 per cent (N=189) of respondents declared to have installed EE windows and 45.6 per cent (N=189) EE boiler.

The responses of the homeowners who install the measure do not differ significantly from the ones who did not. Therefore we are not witnessing a post-hoc rationalization after the decision of investment has been taken.

Conclusions

Traditional policy measures have proven to have a lower impact than expected in the uptake of EE renovation. These rely mostly on information provision and monetary incentives because of the assumption that the dwellers are exclusively rational consumers. On the other hand, new policy approaches such as nudging, that take into account the human limitations, are being tested in various policy fields including energy efficiency (Lourenço et al., 2016, Alain Samson (Ed.), 2018, Lunn, 2013). Most importantly, the new approach is founded on the assumptions that the decision process is guided by a dual-process thinking: deliberative and heuristic. Up to now, the application of behavioural insights from DPMs consisted in a simplified application of biases, ignoring the underlying behavioural mechanisms of the models.

Nevertheless nudges do not address exclusively system 1 thinking but rather the balance between the two. In this paper, we are interested in other aspects and mechanisms of DPMs, such as the balance between systems for reasoning in favour and against the uptake of the EE measures. The results of the survey confirm that arguments in favour of EE measures are mostly deliberative. Another possible interpretation of the results is that the positive arguments framed in a deliberative way are more persuasive, more appealing to be chosen as motivations. However, the arguments against EE measures are not solely heuristic. For the most popular measures the reasons against are balanced. This implies that policies or campaigns to reduce the weight of these negative arguments will have to address both types of reasoning combined. For the EE measures with less market share the negative deliberative arguments outweigh the heuristic ones, yet this difference is less outspoken than for positive arguments.

The positive deliberative arguments prevailing are mostly based on monetary and CO_2 savings. Since both groups, the ones who installed the measures and the ones who did not are aware of these arguments, there is no need for further emphasis during information campaigns. On the other hand, for negative arguments both deliberative and heuristic ones have to be addressed. If the former are mostly investment cost and lack of agency, these can be overcome with information about loans, the latter are biases such as social norm, availability heuristic and affect heuristic that have to be taken into account. For example, one aspect of availability heuristic – the *imaginability* bias regards the objects and events that are not present in the memory but are imagined (Tversky and Kahneman, 1974). Aesthetical advantages of the refurbishments described by the architect might be easier imagined than the benefits of EE measures such as thermal bridges, humidity control, and other technical aspects. Certain information campaigns substitute technical terms of thermal comfort with a warm house, healthy environment that are easier imagined by the homeowners.

Since the survey contains stated preferences, it has the limitation of revealing only how people acknowledge they think. It is not likely for a person to admit or even realize his own heuristic thinking. Nevertheless, the survey reveals different patterns among positive and negative attitudes; among measures with a higher or a lower uptake. There are no statistically significant differences between homeowners who have installed the measures compared to the ones who did not, therefore there is no evidence of post-rationalization effects.

Since biases are already present especially in negative attitudes, there are two main strategies: to avoid them ('First Degree nudge') or to use them in the right direction ('Second Degree nudge') (Baldwin, 2014b). Framing complex information regarding EE renovation in simple terms and avoiding information overload might redirect towards cognitive thinking. If unavoidable, existing biases can be used towards a predictable outcome. For example, for setting energy performance reference, the anchor of nearly zero-energy building is preferable over building stock average. Another example is setting the social norm in terms of positive statistics (how many dwellers have installed a certain EE measure) instead of negative statistics of how inefficient is the building stock overall.

According to Petty R. E. and Cacioppo J.T.'s Elaboration Likelihood Model (Petty and Cacioppo, 1984) the source of the information works as a bias when there is little motivation to engage in rational thinking (low elaboration likelihood). In the case of high elaboration likelihood, the source of information is irrelevant, while the arguments play a role. Thus, it is important to know how motivated and engaged is the audience during the information campaign or the energy advice.

The present application of DPMs in the survey is a first step to unravel the elements that tip the balance in the decision process of EE renovation towards type 1 or type 2 thinking. This first application shows an important potential for further research. Several important aspects are not yet included here. If these methods are to be applied on a larger scale, policy makers have to be aware of the diversity of respondents in the addressed populations. Due to heterogeneity of the population, the impact of nudges is not uniform, occurring the risk to "*discriminate against vulnerable parties*" (Baldwin, 2014a). Thus, further research is necessary for investigating the impact of the three types of nudges on individuals with different characteristics in order to avoid asymmetric impact (Bubb and Pildes, 2014).

Previous BI policies were limited on a list of biases, rather than the underlying mechanisms of DPMs. With the multitude of shortcuts and biases, the suitable design of policy instruments appears to be a particularly challenging task. In this paper we advocate that a better understanding of reasoning and decision making is necessary for each particular context in order to elaborate BI policies. Besides, other aspects of DPMs have to be taken into account such as factors influencing the balance between the two systems. Individual characteristics such as need for cognition, need for closure and need for affect play a role in the balance between system 1/system 2 thinking.

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Chapter 2

Are dwellers deliberative or heuristic in their decisions to invest in energy efficient renovation measures?[3]

Abstract

In order to develop behaviourally-informed policies it is important to understand the mechanisms behind investment decisions in energy efficient (EE) renovation. This study contributes to understanding both deliberative and heuristic thinking of house owners. Unlike previous research, it does not limit to testing biases in isolation, but explores the balance between deliberative/ heuristic thinking. The undertaken survey (n=178) consists of two parts complementing each other: a ranking exercise and a labelled choice experiment (CE).

The ranking exercise consists in pairs of questions with arguments in favour of and against undertaking five EE renovation measures. It aims at verifying whether deliberative or heuristic thinking prevails. For example a deliberative reasoning is “It is good for the environment to save energy”, denoting slow, self-aware thinking based on values, beliefs and personal norms. An example of heuristic thinking is “*All my neighbours have changed their windows*” denoting social norm bias that works as a shortcut. The labelled CE further explores motivations to undertake renovation measures. Respondents had to choose between four measures, with varying levels of the following characteristics: visual changes,

[3] The present chapter is based on the paper “*Are dwellers deliberative or heuristic in their decisions to invest in energy efficient renovation measures*?” by Taranu Victoria, Lizin Sebastien & Verbeeck Griet, published in Consumption, Efficiency & Limits, ECEEE Summer Study Proceedings 2017. The submission was subjected to blinded peer review.

thermal comfort obtained, CO_2 reduction, investment cost, hassle during renovation and source of advice.

By joining insights from both parts of the survey we can assess the consistency and draw conclusions. Results of the ranking exercise show that arguments in favour of uptake are mostly deliberative, whereas arguments against depend on whether the respondent installed the measure or not. The relevance of investment cost and reduction in CO_2 in the adoption intention was reconfirmed by the CE. Since deliberative reasoning such as monetary and CO_2 savings are already perceived as motivations while investment cost is still a barrier for those who did not install the measures, providing information on financing schemes might be more effective than underlining monetary savings.

Introduction

Energy efficiency is central for climate policies and "*it is the one energy resource that every country possesses in abundance.*" (International Energy Agency, 2016). Alongside with renewables, energy efficiency is expected to contribute to achieving the EU proposed target of 40 per cent reduction of CO_2 emissions by 2030 compared to 1990 levels and energy savings of at least 27 per cent (EC, 2016). The residential sector is an important share and accounted for 25 per cent of the final energy consumption in the EU, according to 2014 data (Bertoldi et al., 2016). The minimum requirements of 2010/31/EU Directive (EC, 2010) have translated into substantial improvements for the new construction of dwellings. Yet the existing building stock still has a considerable untapped potential, with 75 per cent of the existing buildings being inefficient and the availability of cost effective renovation measures (EC, 2016).

In the present paper, by referring to energy efficient (EE) renovation measures, we include the following:

- insulation (roof and wall insulation, EE windows)

- production of hot water and energy-efficient heating, ventilation and air-conditioning (HVAC) (EE boilers, solar water heaters, geothermal heat pumps)
- production of renewable energy (photovoltaic solar panels)

The residential building stock of many EU member states, including Belgium, is characterized by high ownership rates of over 70 per cent (BPIE, 2011). Additionally, in Flanders terraced, semidetached and detached houses (94.9 per cent) prevail over apartment blocks (ADSEI, 2018). Therefore, the decision to invest in EE renovation measures is usually an individual decision of the house owner who is also the occupier.

In order to achieve the EU targets, EE renovations have to be scaled up in member states with both 'hard' and 'soft' policy measures (Groote et al., 2016). The former imply mandates, such as mandatory minimum energy performance requirements, while the latter consist mostly in information provision, financing schemes and incentives. Most of the 'soft' measures, such as information campaigns and incentives assume that raising awareness on environmental and economic benefits of the EE renovation is sufficient for increasing its uptake. However, evidence shows that the actual decisions are affected by limited memory, limited attention and limited cognitive abilities (Simon, 2000b). When processing information, people often avoid engaging in effortful, cognitive thinking— System 2, in favour of using a shortcut — System 1 (Darnton, 2008). In this paper we will refer to System 2 thinking as *deliberative* and System 1 thinking as *heuristic*. The latter is intuitive, effortless and automatic and people are usually unaware of it. The rational processing of the information regarding EE renovation might be affected by heuristics and *biases* (Tversky and Kahneman, 1974). Overload and complexity of the information and emotions are only some of the factors that might contribute to a heuristic thinking.

Biases affect the proper estimation of probability and in economics, biases are defined as "*errors when attempting to maximize the utility U(x)*" (Rabin, 1998). People do not always behave as perfect *homo economicus*, as expected from the formula of maximization of expected utility (Simon, 2000b). Many theories in *behavioural economics* explain consumer behaviour using research methods and insights from psychology. The theory of *bounded rationality* (Simon, 1955) takes into account the human limitations such as limited memory, attention and cognitive abilities.

Another theorization of the deviation the modern neoclassical economics assumptions is the *Judgment under uncertainty* (Tversky and Kahneman, 1974, Tversky and Kahneman, 1973). The empirical studies of Tversky and Kahneman provide evidence of the interference of heuristics and biases in the actual decisions. Their main heuristics are *representativeness*, *availability* and *anchoring* with their subsequent biases (Kahneman et al., 1982). Representativeness heuristic explains how people assess the probability of events merely based on the "*degree to which A resembles B*" (Tversky and Kahneman, 1974) ignoring important factors such as sample size and base rate frequency of the outcome. Availability heuristic affects the assessment of the probability of an event by the ease with which it can be recalled (Tversky and Kahneman, 1974). If the event is present in the memory, it is due to *retrievability* bias, otherwise it is due to *imaginability* bias. Anchoring heuristic explains how the assessment of the final value or probability is influenced by the reference point, so that "*different starting points yield different estimates*" (Kahneman et al., 1982). Besides, people often do not take cold-minded and rational decisions because they are affected by emotions – *affect heuristic* (Finucane et al., 2000).

Recently, there is a growing interest to apply these findings to policy making. One of the applications is the commonly known *libertarian paternalism* (Thaler and Sunstein, 2008). It advocates to elaborate policy instruments that preserve the freedom of choice, *nudges*, instead of using mandates (Sunstein, 2014). At the same time, nudging aims to take into account and correct the unrealistic optimism, limited attention and the problem of self-control characteristic to individuals (Sunstein, 2014). Nevertheless, libertarian paternalism is only one of the possible applications of behavioural economics to policy (Lunn, 2013). Traditional policy tools such as mandates or incentives can be elaborated and implemented taking into account the evidence of heuristic thinking. These are the *behaviourally-informed* and *behaviourally-aligned* policy measures (Lourenço et al., 2016).

In order to elaborate effective policy measures for promoting EE renovation, it is necessary to consider both the deliberative and heuristic thinking of the house owners. For this purpose, a survey consisting of a ranking exercise and a choice experiment (CE) was undertaken among Flemish dwellers. The survey does not limit individuating motivations and barriers, but explores the way of reasoning behind the decisions regarding EE renovation measures. Both aspects were cross checked with a ranking exercise and a CE. The present paper is structured as follows: the first section details the method of the survey, the second section summarizes the findings and in the conclusion section the implications to policy are presented.

Method

The data for this research were collected conducting a quantitative survey in Dutch in Belgium. The survey contained three main sections: socio-demographics and housing conditions, a ranking exercise and a CE. In the first section, the respondents and their living situation were profiled. For example, we asked respondents to provide their age, sex, education, whether they are owning or renting, with how many people they live, the construction and the purchase year of the dwelling, whether they have plans to renovate, etcetera. In the second section, the respondents were asked to fill out a ranking exercise (see Ranking exercise subsection for more detail). In brief, the ranking exercise allows finding out whether deliberative or heuristic reasoning is behind arguments in favour of or opposing renovation. In the third section, respondents were first introduced to the concept of a CE by means of an example, followed by a description of the attributes (*Table 9*), after which they had to fill out four choice sets consisting of four labelled alternatives (*Table 10*). The CE further explores the features that stimulate or discourage undertaking renovation measures.

The survey was collected using computer-assisted personal interviews by trained surveyors using random intercept sampling at the largest construction fair in Belgium and at the entrance of a construction materials retail store. Therefore our target population consists of people interested in construction and renovation – 15.2 per cent are currently renovating and 30.9 per cent plan to renovate in the next five years, see *Table 12*. Besides, 43.3 per cent of the sample plan to invest in EE renovation measures in the next five years, a higher percentage compared to 5-13 per cent of the Flemish population as identified in representative samples (VEA, 2013). This data collection technique and sample was deliberative, because literature points out to external conjuncture or major life event (such as purchase of a dwelling, family enlargement, etc.) as triggers to renovation (Wilson et al., 2015). These triggers, at their turn, are conditioned by social practices and everyday domestic life (Shove, 2003). Once a renovation is decided, the house owner has yet to decide how much will be invested in EE renovation measures, alongside investments in amenity renovation measures. Therefore, the house owners interested in renovating are an important target group for information campaigns regarding EE renovation. The data were collected from March to September 2016 and in total, 178 useable responses were obtained.

Ranking exercise

Goal and format

The purpose of the second part of the survey, the ranking exercise, was to investigate the use of system 1/system 2 thinking, when dwellers process information regarding EE renovation measures. We verified whether the arguments in favour of renovation are mostly deliberative and/or the ones against are mostly heuristic. Clues supporting these hypotheses resulted from a focus group on behavioural insights in EE renovation organized in April 2015 by our research group with municipal officials in the context of Werfgoed Living Lab. Among arguments in favour of renovation were listed “to reduce the footprint” (ecological values, beliefs), “house increases in value” (expected utility); while among arguments against the renovation were listed “a lot of cluster, noise, dust” (affect heuristic), “I like how my house looks now” (endowment effect, status quo bias). The aim of the ranking exercise was not to individuate the specific reason or obstacle for the uptake of a particular renovation measure. This kind of analysis has been made in large scale surveys in the Flemish Region (VEA, 2013, Ceulemans and Verbeeck, 2015) and these findings were taken into account when elaborating the survey. Our objective was to sort out the way of reasoning, i.e. to determine whether deliberative or heuristic thinking prevails.

Table 8 Example of ranking exercise item with the explanation of the behavioural models (not visible to respondents) 1.1 Arguments in favour of placing the measure 1.2 Arguments against placing the measure

1.1	*I would install solar water heater because…*			*Behavioural Model/ Insight*
	A	*It is good for environment to save energy*	*D+*	*Value-belief-norm theory*
	B	*Are much cheaper than PV panels*	*H +*	*Anchoring bias*
	C	*All my neighbours installed*	*H+*	*Social norm bias*
	D	*Are cost effective*	*D+*	*Expected Utility*

1.2	*I would not install solar water heater because…*			*Behavioural Model/ Insight*
	A	*It is too difficult to install: dirt, mess*	*H-*	*Affect heuristic*
	B	*It costs too much*	*D-*	*Expected Utility*
	C	*I do not know much about its advantages and disadvantages*	*D-*	*Information deficit*
	D	*A friend has a bad experience installing/ using solar heaters*	*H-*	*Availability heuristic*

The ranking exercise regarded five renovation measures: wall insulation, EE windows, EE boiler, solar panels and solar water heater. For each measure a set of two questions was presented to respondents: with arguments in favour and against the uptake, see *Table 8*. These were based on the most frequently cited reasons by Flemish private owners in large scale surveys (VEA, 2013, Ceulemans and Verbeeck, 2015). Each question included four options, with two deliberative arguments (based on Value-belief-norm, Expected Utility, Information deficit theories) and two heuristic arguments (based on biases such as social norm, loss aversion, endowment bias, mental accounts, affect heuristic). The description of the behavioural models was not visible to respondents who had to rank the four options of the question, assigning 4 to the most preferred option and 1 to the least preferred.

Choice experiment

Goal and format

The goal of the CE was to find out the preferences of people interested in placing EE renovation measures and their attributes. Moreover, we aimed to verify whether deliberative or heuristic arguments were the stronger factor in influencing renovation choices.

Table 9 Description of the attributes presented to respondents before the choice sets

Attribute	***Description***
Changes in the visual aspect of the house	*Changes in the appearance of the dwelling after the measure*
Improvement in the level of thermal comfort	*Improvement in the level of thermal comfort compared to the current state of the dwelling*
CO_2 reduction	*CO_2 reduction in % relative to current levels*
Investment cost	*Total investment cost of the renovation measure in euros for a medium size dwelling in Flanders. It includes the installation costs but does not include public/private funding*
Level of hassle during works	*Level of hassle, cluster, noise during renovation works*
Advice	*Presence or absence of professional advice or non-professional advice from personal contacts*

The experiment was presented to owners and renters by means of detailed stylized hypothetical renovation scenarios for an average Belgian dwelling. This simultaneously avoided unrealistic values to be presented. In CE, respondents are typically presented with several choice sets consisting of multiple alternatives from which they are asked to choose their most preferred alternative. For an example of a labelled choice set, see *Table 10*. The latter shows a translated version of the choice sets that were used in the original, Dutch survey. To fill out a choice set, respondents were required to choose their single, most preferred renovation measure.

Table 10 Example of a labelled choice set

Attributes	***Windows Energy-efficient windows***	***Insulation Roof and wall insulation***	***Heating system Geothermal heat pumps***	***Renewable energy PV panels***
Changes in the visual aspect of the house	*minor*	*minor*	*drastic*	*drastic*
Improvement in the level of thermal comfort	*big*	*big*	*small*	*small*
CO_2 reduction of the dwelling	*75%*	*50%*	*50%*	*75%*
Investment cost	*12000 Euros*	*12000 Euros*	*12000 Euros*	*8000 Euros*
Level of hassle during works	*Little*	*a lot*	*little*	*a lot*
Source of advice	*Expert*	*friend*	*no advice*	*no advice*
CHOICE	*O*	*O*	*O*	*O*

Each choice set contained the following four labelled alternatives: EE windows; roof and wall insulation; geothermal heat pumps and PV panels. Each alternative was described by varying levels of the following characteristics: the degree of visual changes, the thermal comfort obtained, the CO_2 reduction, the investment cost, the hassle during renovation and the source of advice. By capturing which alternatives have been chosen, the relative importance of the different attributes and levels can be estimated (Rose et al., 2008). Compared to other preference elicitation mechanisms, a choice based elicitation format has the advantage of resembling an actual (purchasing) decision (Ward et al., 2011).

Experimental design

Setting up a CE requires creating an experimental design. The latter involves the process of combining attributes and levels into the choice sets, which consist of a number of alternatives, that are presented to the respondents, see *Table 10*. Therefore, the labelled alternatives, which shape the respondents' universal choice set, need to be determined as well as the alternatives' respective relevant attributes and levels. We relied on a literature review, expert interviews and calculations based on standardized pricing for their determination. An overview of the alternatives, their attributes and all possible levels is provided in *Table 11*. A pilot survey (N=303) was performed to ensure proper understanding of the attributes, levels and the elicitation mechanism. The method of the pilot test is described in Chapter 1, section Survey: system 1/ system 2 thinking in decisions regarding energy-efficient renovation. As can be seen from *Table 11*, the attribute development process has led to the conceptualization of six attributes for the four alternatives. A cap on the number of attributes was set at six and on the levels at three as survey length and cognitive burden increases with the previously mentioned numbers (Caussade et al., 2005). The levels that will be used as the base levels in the estimation of dummy coded attributes are underlined. Each respondents was presented first with an example of the choice set, followed by an explanation of the attributes (*Table 9*) and four actual choice sets (*Table 10*). The complete survey is presented in Attachments.

Having acquired the necessary input, one can start the actual statistical design of the experiment. Its two main concerns are the identification and statistical efficiency of the estimates. Identification signals whether main effects and interaction effects between attributes can be (independently) estimated (Hoyos, 2010). For our case, the pilot study showed that selected interaction effects (e.g. investment cost * expert advice) were not statistically significant. Consequently, in the final design, they were omitted. Statistical efficiency aims at providing the maximum accuracy of the estimates for the unknown population parameters, given the available sample size. Efficient designs based on minimization of D-error have recently become increasingly popular.

Table 11 Alternatives, attributes and levels

	Attributes	***Windows Energy-efficient windows***	***Insulation Roof and wall insulation***	***Heating system Geothermal heat pumps***	***Renewable energy PV panels***
Deliberative	***Investment cost (Euros)***	*8000 10000 12000*	*8000 10000 12000*	*12000 14000 16000*	*6000 8000*
Heuristic Affect heuristic	***Hassle during works***	*little a lot*	*little a lot*	*little a lot*	*little a lot*
Heuristic Endowment effect	***Changes in the visual aspect of the house***	*minor drastic*	*minor drastic*	*minor drastic*	*minor drastic*
Deliberative	***Improvement in the level of thermal comfort***	*small big*	*small big*	*small big*	*small big*
Deliberative	***CO_2 reduction***	*25% 50% 75%*	*25% 50% 75%*	*25% 50% 75%*	*25% 50% 75%*
Availability heuristic (friend) / Deliberative (expert)	***Advice***	*friend advice expert advice no advice*	*friend advice expert advice no advice*	*friend advice expert advice no advice*	*friend advice expert advice no advice* -

Formulae for the computation of D-error or D-efficiency can widely be found in literature (Bliemer and Rose, 2011, Kuhfeld, 2010, Rose et al., 2008). In brief, obtaining minimum error or maximum efficiency comes down to minimizing the determinant of the asymptotic variance covariance (AVC) matrix of the used non-linear regression model.

However, this optimization is dependent on the coefficients we are trying to estimate. Hence, there is a need to define priors, which reflect the prior information we might have (e.g. we expect that low hassle will be preferred over high hassle). Using the priors obtained by estimating a conditional logit (CL) on the pilot study as point estimates, we created a main effects only, forced choice, D-efficient design for a CL model using the software program NGENE. A forced choice is justified seeing that people have to choose between competing EE renovation measures in order to achieve a certain energy performance. Most of the EU member states have implemented mandatory minimum energy performance requirements for major renovations, stipulated by the EPBD Directive 2010/31/EU (EC, 2010). In the view of 2030 and 2050 EE targets these minimum requirements will most likely gradually get tighter (EC, 2016). The final experimental design is fractional factorial and contains 24 choice sets. A powerful argument in favour of D-efficient designs has been provided by Bliemer and Rose (2011) as they found empirical proof that pursuing the highest D-efficiency minimizes standard errors on coefficients and thus allows smaller sample sizes compared to the previously used design types. Given the large number of choice sets in the design, it was decided to split the full design over six surveys. Hence, each respondent needed to fill out only four choice sets. Using labelled alternatives, one can estimate alternative-specific (e.g.. a coefficient for investment cost for specific alternatives, for example for PV panels only) or generic coefficient estimates (e.g. a coefficient for investment cost that is the same for all alternatives) (Hensher et al., 2005).

Estimation

To formalize the decision making process, CE have adopted the random utility theory (RUT), which was originally developed by Thurstone (1927), and Lancaster's theory of value (Lancaster, 1966), which allows seeing the value of a good as the sum of the value of its attributes. McFadden (1974) translated the RUT into the mathematical formulation of the CL model. In short, the derivation from RUT to the general expression for the CL model is as follows:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

$$P_{ij} = P\{V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik};\ \forall k \in t\} \tag{2}$$

$$P_{ij} = \frac{exp(\mu\, V_{ij})}{\sum_{k\in t}^{K} exp(\mu\, V_{ik})} \tag{3}$$

$$V_{ij} = \sum_{q\in j}^{Q} \beta_q * X_q \tag{4}$$

RUT assumes that total latent utility U_{ij} for an individual *i* from choosing alternative *j* depends on deterministic part V_{ij} (observable to the researcher) and a stochastic part ε_{ij} (unobservable to the researcher) at the time of choice which for simplicity is omitted (Eq. 1). Hence, the probability P_{ij} that an individual *i* prefers option *j* over all other alternatives *k* in choice set *t* can also be expressed as the probability that the total latent utility of person *i* for option *j* exceeds that of all other alternatives *k* in choice set *t* (Eq. 2). Estimation of this equation requires assumptions to be made about the error terms. The assumption of independently (no cross-correlation) and identically (extreme value type 1) distributed (IID) error terms allows for the convenient closed-form equation of the CL model, which is given in equation 3. Here, μ is a scale parameter which causes different CE results not to be directly comparable. Within a single study it is most often assumed to be equal to one (Ben-Akiva and Lerman, 1985). V_{ij} is commonly assumed to be a linear, additive function with X_q a vector of all attribute levels *q* of alternative *j* and their respective attribute coefficients β_q (Eq. 4). V_{ij} transforms the multi-dimensional attribute vector into a one-dimensional utility measure (Louviere et al., 2000). Consequently, the higher the attribute (level) coefficient, the higher the utility (ceteris paribus), and the higher the probability that an alternative (i.e. a specific attribute-level combination) will be chosen. Note that β_q

is not indexed for the respondents *i*, hence preference homogeneity is assumed when using the CL model.

Findings

Out of 190 collected responses, 12 were incomplete and 178 were complete useable responses (93.7 per cent). The age of the sample varies from 20 to 76 years, with the mean at 39 years. There is a higher share of males with 61.8 per cent compared to 49.4 per cent of the Flemish population (Eurostat Database, 2016) and 62.9 per cent of the respondents have higher education. Yet the sample is rather representative in terms of ownership, with 23.6 per cent of renters compared to 21 per cent of the Flemish population (VEA, 2013). The survey targeted dwellers interested in renovation, therefore 15.2 per cent of the respondents are currently renovating and 43.3 per cent plan to invest in EE renovation measures in the next five years, see *Table 12*.

Table 12 The renovation trends of the sample and the difference between renovation and installing EE measures

		N	***Percentage out of total N=178***	
Renters		*42*	*23.6%*	
House owners	*Have never renovated*	*65*	*36.5%*	*100%*
	Renovated > 10 years ago	*11*	*6.2%*	
	Renovated 5 to 10 years ago	*9*	*5.1%*	
	Renovated < 5 years ago	*24*	*13.5%*	
	Are currently renovating	*27*	*15.1%*	
Plan to renovate in the next 5 years		*55*	*30.9%*	
Plan to invest in energy efficient renovation measures in the next 5 years		*77*	*43.3%*	

Ranking exercise

After socio-demographics, a ranking exercise regarding deliberative and heuristic thinking followed. This part of the survey concerned five EE measures: wall insulation, EE windows, EE boiler, solar panels and solar water heaters. Firstly, the respondents were divided into house owners (76.4 per cent) and renters (23.6 per cent). Secondly, only the house owners were asked which of the following measures they have installed. The measures with the highest uptake are EE windows (54.5 per cent of the total number of respondents), wall insulation (44.4 per cent) and EE boiler (44.4 per cent), see *Table 13*. The responses of the house owners who have installed any of the measures (EXPERIENCES) were analysed separately compared to the house owners who did not and those who are renters (INTENTIONS). This distinction is important because the former regard stated preferences over revealed choices, while the latter are stated preferences over stated choices. Since the number of respondents who have installed solar water heaters are too low for quantitative analysis (9 responses, see *Table 13*), the findings over these measures are based only on INTENTIONS answers.

The hypothesis of the ranking exercise is that the dwellers are mainly deliberative in their positive arguments and are mostly heuristic in their negative arguments:

- Hypothesis 1: Arguments in favour are mostly deliberative $\Sigma(D+) > \Sigma(H+)$
- Hypothesis 2: Arguments against are mostly heuristic $\Sigma(H-) > \Sigma(D-)$

For each EE measure two questions were presented: the first item consisted in arguments in favour (+) and the second in arguments against placing the EE renovation measure (–), see *Table 8*. For each question, two options denote deliberative thinking (D), while the other two heuristic thinking (H). The respondents ranked the four options of each item. The highest ranked option got 4 points, the second best 3 points, then 2, then 1 point. The points of the two deliberative options are summed (ΣD), as are the points of the heuristic options

(ΣH). The possible outcomes of the sums for ΣD are 7 (the two highest ranked options are deliberative), 6 (highest and third ranked option are deliberative), 5, 4 and 3, and then ΣH respectively equals 3, 4, 5, 6, 7.

Table 13 Uptake of the five EE renovation measures of the ranking exercise among homeowners

	N	*Percentage out of total N=178*
Wall insulation	*79*	*44.4%*
EE windows	*97*	*54.5%*
EE boiler	*73*	*41.0%*
Solar panels	*35*	*19.7%*
Solar water heater	*9*	*5.1%*

INTENTIONS include the responses from renters and from the house owners who did not install the measure. Yet, renters might have different external constraints than house owners. In order to verify if their responses are different, we have performed t-tests for independent (unpaired) samples. We have checked if the difference in means is not equal to 0:

$$\Sigma D \text{ renters} - \Sigma D \text{ owners} \neq 0$$

$$\Sigma H \text{ renters} - \Sigma H \text{ owners} \neq 0$$

for both arguments in favour of (D+ or H+) and against installing (D– or H–), for each of the 5 measures. The difference was not significant for any of the t-tests. Therefore, we can analyse the responses of the renters together with the ones of the house owners who did not install it, both belonging to the category INTENTIONS.

In order to verify the two hypotheses, Wilcoxon signed-rank tests for paired sample were performed to verify whether differences ΣD–ΣH for each respondent are different from 0. These tests were conducted for each of the five

EE measures: for the positive arguments and negative arguments of the EXPERIENCES and INTENTIONS groups respectively. Wilcoxon signed-rank test is a non-parametric statistical test, chosen because variables did not meet the assumption of normal distribution. The statistical analysis was computed using RStudio version (2016). The results are summarized in *Table 14* and ***Table 15***. For the sample of EXPERIENCES the number of respondents who have installed solar water heaters was insufficient to perform the statistical analysis.

For all the measures the first hypothesis was confirmed: the dwellers are more deliberative in their positive arguments. This is common for both house owners who installed the measure (EXPERIENCES) and the ones who did not or who are renters (INTENTIONS). These deliberative arguments in favour are based mainly on monetary motivations (*"I want to save money on heating"*) or environmental motivations (*"It is good for environment to save energy").* Therefore, independently whether they installed the measures or not, dwellers are equally aware of the monetary and CO_2 savings and they prevail over heuristics.

Table 14 Results of the ranking exercise.
*EXPERIENCES – responses of homeowners who installed the measure. Results of the Wilcoxon signed-rank test *** p-value <0.001, ** p-value < 0.01, * p-value< 0.05. Cohen's classification of effect sizes 0.1 (small effect), 0.3 (moderate effect) and 0.5 (large effect).*

	Positive Deliberative-Heuristic			Negative Deliberative -Heuristic		
	p-value	Effect size	Outcome	p-value	Effect size	Outcome
Wall insulation	<0.001***	Large 0.532	Σ(D+)> Σ(H+)	0.6102	Small 0.0577	Σ(D-)> Σ(H-)
EE windows	<0.001***	Large 0.708	Σ(D+)> Σ(H+)	0.1661	Small 0.141	Σ(D-)= Σ(H-)
EE boiler	<0.001***	Large 0.623	Σ(D+)> Σ(H+)	0.6332	Small 0.0562	Σ(D-)= Σ(H-)
PV panels	0.0137**	Large 0.417	Σ(D+)> Σ(H+)	0.03515**	Large 0.356	Σ(D-)> Σ(H-)
Solar water heater	-	-	-	-	-	-

Regarding the negative arguments the second hypothesis was not confirmed: the heuristic arguments do not prevail. It is important to remark that here the responses between house owners who have undertaken the measure (EXPERIENCES) differ from ones who did not (INTENTIONS). The former show a balanced deliberative and heuristic thinking, whilst for the latter group deliberative thinking still prevails for all the measures except for EE boiler, see *Table 14* and ***Table 15***.

Table 15 Results of the ranking exercise.
*INTENTIONS – responses of homeowners who did not install the measure. Results of the Wilcoxon signed-rank test *** p-value <0.001, ** p-value < 0.01, * p-value< 0.05. Cohen's classification of effect sizes 0.1 (small effect), 0.3 (moderate effect) and 0.5 (large effect).*

	Positive Deliberative-Heuristic			*Negative Deliberative -Heuristic*		
	p-value	*Effect size*	*Outcome*	*p-value*	*Effect size*	*Outcome*
Wall insulation	*<0.001****	*Large 0.622*	*Σ(D+)> Σ(H+)*	*0.0039****	*Moderate 0.382*	*Σ(D-)> Σ(H-)*
EE windows	*<0.001****	*Large 1.124*	*Σ(D+)> Σ(H+)*	*0.04862**	*Moderate 0.324*	*Σ(D-)> Σ(H-)*
EE boiler	*<0.001****	*Large 1.02*	*Σ(D+)> Σ(H+)*	*0.7199*	*Small 0.0452*	*Σ(D-)= Σ(H-)*
PV panels	*<0.001****	*Large 0.745*	*Σ(D+)> Σ(H+)*	*<0.001****	*Large 0.701*	*Σ(D-)> Σ(H-)*
Solar water heater	*<0.001****	*Large 0.715*	*Σ(D+)> Σ(H+)*	*<0.001****	*Large 0.657*	*Σ(D-)> Σ(H-)*

A possible explanation of the different reasoning between EXPERIENCES and INTENTIONS in terms of obstacles might be the investment cost. While both groups are aware of the monetary and environmental savings as main motivations, the respondents who did not install the measures are more concerned about the investment cost. Another possible explanation of this finding is that the house owners who installed the measure (EXPERIENCES) are more self-aware of their own biases, since the responses are self-reported preferences. Responses coincide for the PV panels measure, in both cases deliberative arguments prevail with a large effect size.

Choice experiment

The estimated utility functions take the following form (see equations 5-8) with ASC being the alternative specific constant and $\beta_{\#}$ the coefficient estimate for that alternative and attribute (level). The significant attributes or attribute levels are indicated in bold to facilitate legibility. Note that all dummy level coefficient estimates, indicated by the d_ prior to the matching the attribute level, should be interpreted relative to the omitted base levels.

U(Energy-efficient windows)= ASC1 + β_{11}*d_drastic_visual_change + β_{12}*d_big_thermal_comfort_improvement + β_{13}*d_lots_of_hassle + β_{14}*d_friend_advice + β_{15}*d_expert_advice + β_{16}*d_50%_CO_2_reduction + β_{17}*d_75%_CO_2_reduction + β_{18}*investment_cost (5)

U(Roof and wall insulation)= ASC2+ β_{21}*d_drastic_visual_change + β_{22}*d_big_thermal_comfort_improvement + β_{23}*d_lots_of_hassle + β_{24}*d_friend_advice + β_{25}*d_expert_advice + β_{26}*d_50%_CO_2_reduction + β_{27}*d_75%_CO_2_reduction + β_{28}*investment_cost (6)

U(Geothermal heat pumps)= ASC3+ β_{31}*d_drastic_visual_change + β_{32}*d_big_thermal_comfort_improvement + β_{33}*d_lots_of_hassle + β_{34}*d_friend_advice + β_{35}*d_expert_advice + β_{36}*d_50%_CO_2_reduction + β_{37}*d_75%_CO_2_reduction + β_{38}*investment_cost (7)

U(PV panels)= β_{41}*d_drastic_visual_change + β_{42}*d_big_thermal_comfort_improvement + β_{43}*d_lots_of_hassle + β_{44}*d_friend_advice + β_{45}*d_expert_advice + β_{46}*d_50%_CO_2_reduction + β_{47}*d_75%_CO_2_reduction + β_{48}*investment_cost (8)

The results of the estimation of an alternative-specific CL model are presented in *Table 16*. For brevity only the significant estimates are displayed. The results pick up on the main effects that are easiest to detect and hence are most likely to have the strongest effect on choices in a follow-up study which allows estimating the sign and size of all significant alternative-specific coefficient estimates. From these results, we can infer the following conclusions. Firstly, visual changes play a significant role in the decision to install energy efficient glazing and as expected people prefer minor changes over drastic changes. Secondly, our respondents do not strongly associate greenhouse gas savings with installing energy efficient glazing, whereas they do for the other alternatives under study. Moreover, as expected, larger savings are preferred over smaller ones. Thirdly, the expected negative coefficient for investment cost could be established for all alternatives, but for windows and PV. The similarity in the size and sign of the coefficients for heat pumps and insulation points out that over the studied price range people are equally price sensitive for those two alternatives. Finally, only for windows could expert advice be identified as a significant factor in influencing choice.

Table 16 Results of an alternative-specific model

Coefficient	***Estimate***	***Standard error***
Windows: drastic changes in the visual aspect of the house	*-0.46**	*0.21*
Windows: expert advice	*0.65***	*0.25*
Roof and wall insulation: 75% reduction in CO_2	*0.59**	*0.27*
Roof and wall insulation: investment cost	*-0.0002****	*0.0006*
Geothermal heat pumps: 75% reduction in CO_2	*0.89**	*0.44*
Geothermal heat pumps: investment cost	*-0.0002**	*0.0007*
PV: 75% reduction in CO_2	*0.60**	*0.27*
Log-likelihood=-915.00 *Pseudo R^2 = 0.05* * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001		

We also estimated a generic model seeing that for some attributes we did not obtain any significant information yet. The utility function for a generic model estimates a single coefficient for each attribute or attribute level, irrespective of the alternative (see equations 9-12). This specification assumes people's attribute (level) weights do not differ significantly depending on the alternative. Based on the overlap in the confidence intervals on the alternative-specific coefficient estimates this assumption is supported empirically.

U(Energy-efficient windows)= ASC1 + β_1*d_drastic_visual_change + β_2*d_big_thermal_comfort_improvement + β_3*d_lots_of_hassle + β_4*d_friend_advice + β_5*d_expert_advice + β_6*d_50%_CO_2_reduction + β_7*d_75%_CO_2_reduction + β_8*investment_cost
(9)

U(Roof and wall insulation)= ASC2+ β_1*d_drastic_visual_change + β_2*d_big_thermal_comfort_improvement + β_3*d_lots_of_hassle + β_4*d_friend_advice + β_5*d_expert_advice + β_6*d_50%_CO_2_reduction + β_7*d_75%_CO_2_reduction + β_8*investment_cost
(10)

U(Geothermal heat pumps)= ASC3+ β_1*d_drastic_visual_change + β_2*d_big_thermal_comfort_improvement + β_3*d_lots_of_hassle + β_4*d_friend_advice + β_5*d_expert_advice + β_6*d_50%_CO_2_reduction + β_7*d_75%_CO_2_reduction + β_8*investment_cost
(11)

U(PV panels)= β_1*d_drastic_visual_change + β_2*d_big_thermal_comfort_improvement + β_3*d_lots_of_hassle + β_4*d_friend_advice + β_5*d_expert_advice + β_6*d_50%_CO_2_reduction + β_7*d_75%_CO_2_reduction + β_8*investment_cost
(12)

Table 17 Results of a generic model

Coefficient	*Estimate*	*Standard error*
Windows: ASC	*0.40***	*0.14*
Roof and wall insulation: ASC	*0.72****	*0.13*
Geothermal heat pumps: ASC	*0.27*	*0.22*
drastic change in the house's appearance	*-0.13*	*0.12*
big thermal comfort improvement	*0.30***	*0.001*
lots of hassle	*-0.08*	*0.08*
friend advice	*0.003*	*0.10*
expert advice	*0.30***	*0.11*
50% CO_2 reduction	*0.15*	*0.13*
75% CO_2 reduction	*0.54****	*0.12*
Investment cost	*$-0.12*10^{-3}$****	*$0.3*10^{-4}$*
Log-likelihood = -925.36 *Pseudo-R^2 = 0.06* ** p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001*		

The results of the CL estimation of a generic specification are shown in *Table 17*. All attribute coefficients have the expected signs, i.e. negative for higher investment costs, positive for expert advice, positive for a 75 per cent reduction in CO_2 emissions, positive for a 50 per cent reduction in CO_2 emissions (but not significant), negative for drastic visual changes (but not significant), positive for thermal comfort improvements, negative for lots of hassle (but not significant) and positive for friend advice (but not significant). Regarding the ASC we find that the labels EE windows and roof and wall insulation have a statistically significant positive effect on utility when compared to the effect of the label PV panels. Moreover, the size of the effect is significantly different from each other. Hence, our respondents have the following relative renovation preference: (1) wall and roof insulation (2) installation of EE windows, (3) PV panels or geothermal heat pump heating system. To calculate attribute importance, we need to perform the following steps: (1) calculate the utility range per attribute; (2) sum up the utility ranges; (3) divide the attribute utility range by the sum of the utility ranges. If we only take the significant attributes into account, this procedure leads to the following attribute ranking in a decreasing order of importance: investment cost (69.84 per cent), CO_2 reduction (14.29 per cent), and tied are thermal comfort improvement and energy advice. Note, however, that the labels, which are captured by the ASCs, are at least as powerful in determining choices as the attributes.

Conclusions

Previous 'soft' policy measures of information provision and incentives had a limited impact on encouraging the uptake of EE renovation. Most of them are conceived and implemented based on the assumption that house owners are exclusively rational. Our survey aims for a better understanding of both deliberative and heuristic reasoning behind the decisions to install or not to install EE renovation measures. These findings, alongside with other quantitative research further needed, can contribute to the elaboration and implementation of behaviourally-informed policies (Lourenço et al., 2016).

Since the survey contains stated preferences, with the risk of revealing only how people acknowledge they think. Another limitation of the study consists in a certain degree of subjectivity in the design of the ranking exercise when classifying arguments into deliberative and heuristic. Certain salient aspect of each argument, for example price, could prevails. To compensate for this limitation, the CE accompanied the ranking exercise in order to provide insights on which single aspect influence the decision making, while the ranking exercise focused on the balance between the two systems.

From the generic CE we can derive the conclusions described below. Despite the information provided by the attributes in the CE, respondents still largely base their choices on associations with the chosen alternative which are already present in their minds at the time of surveying seeing that the ASCs have the largest impact on utility. Furthermore, the finding that the ASC for geothermal heat pumps is not significantly different from that of PV panels reflects that both of these options are less chosen independently of their characteristics compared to the other alternatives. This might reflect a more negative attitude towards these technologies. On average the respondents were found to be influenced strongly in making the (positive) choice to renovate by deliberative arguments, i.e. investment cost, reduction in CO_2. It is important to note that findings from the ranking exercise show that deliberative arguments prevail for motivations. Therefore, even though monetary and environmental factors play an important role in the decision making, these are already perceived in a positive way. At the same time, the dwellers who installed the measure and those who did not show different reasoning in terms of barriers. Only for the latter group investment costs and other deliberative arguments prevail over heuristics. For these reasons, providing information on financing schemes might be more effective than underlining monetary savings during information campaigns. Another possible explanation of this finding is that the house owners who placed the measure are more self-aware of their own biases. Yet, if aware of, biases can be overcome, an example of availability heuristic, "A friend has a bad experience installing/ using solar heaters" could be debunked with statistical data. An alternative to avoiding biases is to use them in the right direction. For example, Living Lab Housing Renovation programmes (Groote et al., 2016) can set up new, positive, retrievable in the memory examples.

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Conclusions Part 1

Dual-process thinking and its implications to energy renovation policies

BI policies, including nudges, are based on the assumptions and findings of dual-process behavioural models (DPMs). Our approach proposed a more in depth analysis of DPMs, especially on the balance between system 1/system 2 thinking rather than study of biases in isolation.

Table 18 summarizes the main differences between type 1/ type 2 processes according to various DPMs. Most of the DPMs assume a parallel and concurrent processing of the information, while the model of Evans J. St. B. T. considers additional preattentive processes of type 1 that inform deliberative, type 2 thinking (Evans, 2006).

The main factors influencing the balance between system 1/system 2 thinking can be divided into:

- Type of information (heavy cognitive load, information overload and uncertainty of the outcomes,)
- Emotions
- Situational factors such as time pressure, noise, etc.
- Characteristics of the individual - need for cognition, need for closure and need for affect.

Literature review regarding DPMs was completed with a survey regarding decisions to invest in EE measures - wall insulation, EE windows, EE boiler, PV panels, solar water heater. Arguments in favour and against the uptake of these measures were presented to dwellers, framed in a deliberative (based on Value-belief-norm, Expected Utility theories) and heuristic way (based on biases such as anchoring, availability, affect heuristic, social norm).

Table 18 Properties of Type 1 and type 2 processes according to various DPMs. Adapted from (Evans and Frankish, 2013, Stanovich and West, 2000, Dolan et al., 2010, Evans, 2008)

Type 1 processes	***Type 2 processes***
Heuristic	*Analytic*
Intuitive	*Deliberative*
Associative	*Rule based*
Automatic	*Controlled*
Relatively fast	*Relatively slow*
Low effort	*High effort*
Adaptive unconscious	*Conscious, self-aware*
Evolutionary old	*Evolutionary recent*
Shared with animals	*Distinctively human*
Nonverbal	*Linked to language*
Implicit, tacit knowledge	*Explicit knowledge*
Contextualized	*Abstract*
Impulsive	*Reflective*
Default process	*Inhibitory*
Emotional	*Deductive*
Experiential	*Rational*
Holistic	*Analytic*
Stereotypical	*Egalitarian*
Independent of general intelligence	*Linked to general intelligence*
Independent of working memory	*Limited by working memory capacity*

The initial hypothesis was confirmed for positive arguments, where deliberative thinking prevails. For negative arguments the results vary according to the type of measure. For the measures with a lower uptake on the market (wall insulation, PV panels and solar water heater) rational arguments still prevail. For EE windows and boilers the rational and heuristic thinking are balanced. It is important to underline that the latter measures are the most popular with respectively 56.9 per cent of respondents declared to have installed EE windows (compared to 76.8 per cent in Flanders) and 45.6 per cent EE boiler (compared to 58.1 per cent in Flanders). The positive deliberative arguments prevailing are mostly based on monetary and CO_2 savings. Since both groups, the ones who installed the measures and the ones who did not, are aware of these arguments, there is no need for further emphasis during information campaigns. On the other hand, for negative arguments both deliberative and heuristic ones have to be addressed. Nudges do not only address system 1 thinking but rather the balance between the two. If the negative deliberative arguments are mostly investment cost and lack of agency and can be overcome with information about loans, the negative heuristic ones are biases such as social norm, availability heuristic and affect heuristic and have to be taken into account.

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Part 2

Behaviourally-informed policies

Introduction Part 2

The second part of the thesis aims to investigate BI policies, using the new version of the Flemish EPC as a case study. The EPC scheme is mandatory in the EU member states and it could potentially have a big aggregative impact on renovation decisions. The version of the certificate that is in use in Flanders since 2008 will be substituted in January 2019 with a new version (Vlaamse overheid, 2018) that at the moment of the studies was under elaboration. The control conditions of the two laboratory studies are different, being the versions provided by the Flemish Energy Agency (Vlaams Energieagentschap VEA), the trial versions at difference stages of the policy elaboration. Based on research, including the present one, the certificate version that will be launched in January 2019 has been modified, compared to the preliminary test versions, see Conclusions Part 2.

The certificate contains an energy indicator, recommendations for improving its EE and other technical information. The studies will concern only the first and the third page, containing the energy indicator and the recommendations.

Firstly, a qualitative study consisting in a comparative analysis of nine European EPCs was undertaken with the aim to individuate the array of possible information frames and potential nudges, see Chapter 3. Subsequently, these findings were analysed in the format of a focus group with local experts in technical and behavioural aspects in order to adjust to the local context and narrow down the hypotheses to be tested.

The second stage of the research consisted of two quantitative studies. Laboratory experiments were chosen over RCTs because the former allow to determine the behavioural mechanism besides determining which EPC version provides better results in achieving the goals of the policy tool. The first study with students of Architecture Faculty served as trial tests and further reduced the number hypotheses to be tested in the subsequent laboratory experiment. Ten experimental conditions were presented in order to detect existing biases and nudges to overcome or exploit the biases (Chapter 4). The student sample may have been inappropriate for renovation decisions, therefore the second laboratory experiment implied homeowners. This laboratory experiment aimed to validate previous findings and determine the behavioural mechanism with 2x2 factorial design (Chapter 5).

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Chapter 3

A closer look into the European Energy Performance Certificates under the lenses of behavioural insights – a comparative analysis[4]

Abstract

The Energy Performance Certificate (EPC) aims to promote energy efficiency in the residential sector by allowing prospective buyers and renters to compare dwellings in terms of current and potential energy performance. Yet, the impact of the EPC on the purchase and renovation decisions is limited. The research hypothesis is that the framing of the information is an important determinant alongside the calculation method and the training of the certifiers. By framing of the information is meant the content, the wording and the layout. The present paper analyses how the technical information is translated for the dwellers and focuses on a possible heuristic interpretation of the information. Firstly, a theoretical framework of deliberative and heuristic thinking is presented, with its implication to policy making. Secondly, the findings of a qualitative inquiry of existing certificates, undertaken in two phases (a comparative analysis and a focus group) are presented. The certificates of nine European countries/regions revealed a wide range of information framings and potential nudges that have been analysed through the 'lenses' of behavioural insights. Even if nudging is not a purpose, the system 1 thinking might influence the understanding of the

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[4] The present chapter is based on the article "*A closer look into the European Energy Performance Certificates under the lenses of behavioural insights – a comparative analysis*" by Taranu Victoria & Verbeeck Griet, published in the Journal Energy Efficiency in October 2017.

information since no message is neutral. Contrary to common misinterpretation that nudging exploits exclusively individual's system 1 thinking, certain type of nudges address the rationality of the people by avoiding an existing bias. These findings were analysed in depth in a focus group with experts. Recommendations are provided in order to render the EPC an effective communication tool with the dwellers.

Introduction

One of the key policy instruments for promoting energy efficiency in the building sector in Europe is the Energy Performance Certificate (EPC). The certificate was introduced first with the Directive 2002/91/EC (EC, 2002) that stipulated that member states should ensure the certificate "*is made available to the owner or to the prospective buyer or tenant when the building is constructed, sold or rested out*". The implementation of the EPC was reinforced with the recast 2010/31/EU (EC, 2010) that required the inclusion of the energy performance information at the moment of advertisement the property for sale or for rent.

All EPCs contain an energy performance indicator and recommendations for the improvement of the energy efficiency. Both directives specify that besides the energy performance, the certificate has to include reference values such as minimum energy performance requirements "*in order to make it possible for owners or tenants of the building or building unit to compare and assess its energy performance*"(EC, 2010). Therefore, the EPC is an information provision tool that aims to correct the market failure of asymmetric information. Besides, the recommendations might correct individual failures such as bounded rationality and bounded willpower (Bubb and Pildes, 2014) and encourage the uptake of energy efficiency measures.

Up to now, various EU reports and projects have monitored the implementation of the certificate and its impact on the real estate market and on the uptake of energy efficiency measures (Mudgal et al., 2013, RenoValue). Literature shows mixed results or limited influence on the price of selling and renting (Christensen et al., 2014, Mudgal et al., 2013, Wahlstrom, 2016, Harsman et al., 2016), as well as on energy renovation decisions (Christensen et al., 2014, Wade and Eyre, 2015).

There might be various causes of the low influence of the certificate. Each member state had a certain degree of freedom in deciding on the calculation method, the content and the layout. Most of the reports and projects focus on quality assurance of the calculation method and the professional training of the energy experts (Arcipowska et al., 2014, Maivel et al., 2016, Harsman et al., 2016). At an early stage of implementation, studies have analysed existing EPCs and hypothesised over its future implementation (BPIE, 2010, Perez-Lombard et al., 2008). Their main focus was WHAT should be included rather than HOW.

Yet few of the EU projects and reports that follow the implementation of the certificate consider its quality of communication. One of the exceptions is the EU project IDEAL EPBD: Improving Dwellings by Enhancing Actions on Labelling for the EPBD (IDEAL EPBD Project). In the framework of the project, the impact of the EPC on the house owners was explored (Backhaus et al., 2011). The parameters were: how easy it is to understand the certificate, its perceived usefulness and trust. Surveys of the IDEAL EPBD project revealed the trade-off between intelligibility on one hand and usefulness and trust on the other hand. The certificates of the UK and the Netherlands are easy to understand and the recommendations are easy to remember, while at the same time, these are not perceived as useful. The certificates of Germany and Denmark show an opposite pattern. Besides, the German EPC contains more technical terms and concepts, that renders it more difficult to understand in comparison with the others. Yet, the certificates of Germany and Denmark with more detailed and tailored information are perceived as a reliable and trustful source of information (Backhaus et al., 2011). These findings regard previous versions of the EPCs compared to our study since the data of the surveys date back to 2008. Nevertheless, it underlines the importance of how to render the technical information more accessible, without losing its credibility and trust.

Another report that explores the content and the layout of the EPCs is the report on the implementation of the EPBD (Sutherland et al., 2015). Regarding the recommendations, there is the trade-off between the cost and content of the certificate. Personalized energy advice is more costly than a list of standardised recommendations. The report states that the layout and user-friendliness are crucial, recommending less technical terms and icons. It explores certain aspects of the content and layout of the certificates, yet it states the need for further research in order to adapt it to the needs of the users.

The research hypothesis of our research is that the framing of the information is an important explanatory factor for the effectiveness of the EPC, alongside calculation method and quality assurance. Information framing of the following two key messages of the EPC will be analysed under the optics of behavioural insights, taking into account system 1/system 2 thinking:

- Energy performance indicator
- Recommendations for measures to improve the energy performance (e.g. wall insulation)

In the present paper, by framing of the information is meant the following aspects: the content, the wording and the layout, since in the case of the energy performance indicator these are inseparable. The article summarizes and discusses the findings of a qualitative analysis in two phases: a comparative analysis and a focus group. The comparative analysis of the EPCs of nine different countries/regions had the aim to identify and compare the wide variety of possible information framings of the energy performance indicator and of the recommendations. The analysis takes into account that dwellers have both rational and heuristic thinking and might have biases in their interpretation of the information. The findings of the first phase were further discussed in a focus group with experts both in energy efficiency and in behavioural sciences. Besides gaining additional insights on the potential nudges and biases, the focus group aimed to gain insights on which information framings must be tested in an experimental way with dwellers. Finally, recommendations for improving the EPC as a communication tool are provided.

Theoretical framework

Dwellers as both rational and heuristic decision makers

Many policies promoting energy efficiency in the residential sector rely on the assumption that house owners are exclusively rational. Yet the actual decisions are affected by limited memory, limited attention and limited cognitive abilities (Simon, 2000a). When processing the information, people often avoid engaging in effortful, cognitive thinking — *System 2,* due to a shortcut — *System 1* (Thaler and Sunstein, 2008). The latter is heuristic, effortless and automatic and people are usually unaware of it. Even though System 1 is useful for taking small decisions in our everyday life in a fast manner, it might be inappropriate for important decisions such as purchase or renovation of a dwelling. The rational processing of the information of the EPC might be affected by unconscious errors, commonly named biases (Tversky and Kahneman, 1974). Characteristics of the certificate, such as complexity of the information, choice overload, lack of salience are only some of the factors that might contribute to system 1 thinking.

Besides, people do not always take cold-minded and rational decisions because they are affected by emotions – affect heuristic (Finucane et al., 2000). The influence of the emotions might be underestimated because people often rationalise the decision made based on emotions with rational arguments afterwards. "*We don't see "A house": We see a handsome house, an ugly house. … We choose houses we find attractive and then justify these choices by various reasons.*"(Zajonc, 1980). Therefore the information regarding the energy performance of the house might have a smaller impact on the purchase decision even if available. Certain aspects of the certificate, such as the image of the dwelling, might play a role in this regard.

If in general biases influence the correct estimation of probability, in economic applications, biases are *"errors when attempting to maximize the utility U(x)"* (Rabin, 1998). For example, temporal discounting is characteristic to investments where the benefits occur in the future (Frederick et al., 2002). These savings of the recommended energy efficiency measures of the EPC might weigh much less than the initial investment, even for positive net present values (BIT, 2011b).

Information framing does not equal, but it might include the framing effect bias. In certain cases, the decisions are affected by the wording of the message in positive or negative terms (Kahneman and Tversky, 1979). An example is presenting the same statistics in "97 per cent of success rate" or "3 per cent chances of failure rate" that might influence the decision-making process.

Existing policies that take into account behavioural insights

The most well-known application of findings from behavioural economics to policy is *nudging*. According to R. Thaler and C. R. Sunstein, a nudge is "*any aspect of the choice architecture that alters people's behaviour in a predictable way*" (Thaler and Sunstein, 2008). It belongs to the libertarian paternalism approach, the main principle of which is to incline toward the best solution, without forbidding the other choices. According to C.R. Sunstein, anything that does not involve a strong incentive while preserving the free choice qualifies as a nudge (Sunstein, 2014). Other scientists, among whom R. Bubb and R. Pildes, claim that this definition is too broad. They reckon that a nudge should not affect the decision of a *homo economicus* (Bubb and Pildes, 2014). Therefore, we propose the following definition: any change in the choice architecture that affects heuristic thinking or the balance between System 1 and System 2 thinking.

A common misinterpretation of the nudge is to consider that it only exploits the biases. Nudges can also enhance the cognitive processing of the information by avoiding complexity and certain biases. These are according to R. Baldwin (Baldwin, 2014b) — first degree nudges, see *Table 19*. Another definition of first degree nudge is the one aiming to '*debias*' the decision-maker (Lunn, 2013). C.R. Sunstein refers to this type of nudges as System 2 nudges, or 'educational nudges' (Sunstein, 2016). Yet, information provision only qualifies as a '*first degree nudge'*, if aiming to avoid a certain bias, see *Table 19*. Exemplifying is the EAST method (Make it Easy, Attractive, Social and Timely) that advocates for rendering the message simple and salient (Hallsworth et al., 2014).

Table 19 Three types of nudges. Adapted from R. Baldwin (Baldwin, 2014b)

	First degree nudge	*Second degree nudge*	*Third degree nudge*
Relation to bias	*Avoid an existing bias*	*Use an existing bias towards a predictable outcome*	*Induce a new bias*
System 1 (heuristic)/ System 2 (rational)	*From System 1 towards System 2*	*System 1*	*From System 2 towards System 1*
Example	*Salience*	*Default*	*Graphic warning*

The second degree nudges aim to use an existing bias towards a predictable outcome, an example being the default nudge, (see *Table 19*). There is evidence that people go along with the default option, therefore setting the 'right' default temperatures for the heating and cooling systems would be effective (BIT, 2011b). Sunstein refers to defaults as System 1 nudges, because they target automatic, heuristic processing (Sunstein, 2016).

Another example of System 1 nudges are graphic warnings, for example on the tobacco packaging. According to Baldwin's categorization, these are third degree nudges (*Table 19*) because they induce a new bias (Baldwin, 2014b), an emotional association in this case. The implication of the three types of nudges with regard to the EPC will be further exploited in the subsection HOW: the role of nudges.

In the last decade there was a growing interest to apply libertarian paternalism to policy in many European countries such as UK, France, Denmark, Ireland, Sweden, Norway (Lunn, 2013). Nudging has been applied in many areas of policy making such as consumer protection, finance, taxation and health, yet their applications in the context of energy have been limited (BIT, 2015, BIT, 2016, Lourenço et al., 2016).

Nevertheless, limiting the application of behavioural economics exclusively to a hands-on list of biases is rather reductive. It is important to keep in mind the mechanisms and the assumptions behind the behavioural models (Taranu and Verbeeck, 2016). For example, the balance between system 1/system 2 thinking depends not only on the characteristics of the message, but also on characteristics of the individuals such as need for cognition (Mannetti et al., 2007), need for closure (Cacioppo et al., 1984) and need for affect (Maio and Esses, 2001). These factors have to be taken into account in order to avoid an asymmetric impact in the implementation of the policy instrument (Baldwin, 2014b).

Nudging is only one of the possible applications to policy, that preserves the freedom of choice (Sunstein, 2014). Behavioural insights can also serve as basis for certain mandates, without being committed to political doctrine of choice preservation that is characteristic to libertarian paternalism (Lunn, 2013, Bubb and Pildes, 2014). Besides the choice of the instrument, behavioural insights might influence the way the policy instrument is implemented. The recent EU Report underlines the possibility for an implicit consideration in elaborating traditional policy tools such behaviourally-informed initiatives and behaviourally-aligned initiatives (Lourenço et al., 2016). Nevertheless, while the efficacy of nudges can be tested with RCTs, the other applications are more difficult to assess, since the effect of the behavioural insight can hardly be isolated from the complex reality (Lunn, 2013).

Methodology

The EPC is addressed to house owners and prospective buyers and renters, who will receive the certificate when deciding to buy or rent a property. Therefore, by reading the certificate they must be able to understand the current and potential energy performance of the dwelling without assistance from energy experts. Our research analyses how the technical information of the energy performance is translated for the dwellers and focuses on a possible rational or heuristic interpretation of the information (see section Theoretical framework).

The qualitative research consists of two phases: a comparative analysis across nine European EPCs, (subsection Methodology of the comparative analysis) and a focus group with experts (subsection Methodology of the focus group). The comparative analysis revealed a wide range of possibilities in terms of information framings and potential nudges. During the focus group, the findings of the comparative analysis were discussed under the optics of the application to the Flemish EPC. Additional insights were gained regarding the existing version of the certificate with regard to its intelligibility and impact. Another aim of the focus group was to narrow down the wide range of possible information framing derived from the comparative analysis. These framings will be further on tested with experiments on the Flemish EPC in the third phase of the research.

Methodology of the comparative analysis

The comparative analysis of the nine European EPCs (Germany, the Netherlands, the UK, Spain, Romania, Denmark, France and two Regions: Lombardy and Flanders) takes into account the possible system 1 interpretation of the information by the dwellers. Since EPCs are subject of changes, it should be noted that the versions in discussion are as of June 2015. In the choice of the certificates was taken into account their heterogeneity, both in content, length and geographical distribution.

The information framings of the certificates were analysed from the point of view of potential biases and nudges. The latter resulted from a literature review of behaviourally informed policies in energy efficiency and residential energy. Based on the three types of nudges, previously discussed in section Theoretical framework, the following framework was elaborated and applied in the comparative analysis of the EPCs:

- First degree nudges (Baldwin, 2014b):
    - Simple, intelligible messages (BIT, 2011b, Dolan et al., 2010, Lunn, 2013); Salient information (Hallsworth et al., 2014, Dolan et al., 2010)
- Second degree nudges (Baldwin, 2014b):

    - Social norm (Hallsworth et al., 2014, Dolan et al., 2010), temporal discounting (BIT, 2011b) and default (Dolan et al., 2010, Frederiks et al., 2015)

- Third degree nudges:
    - Anchoring (Thaler and Sunstein, 2008, Lunn, 2013), endowment effect (Lourenço et al., 2016)

- Relate the energy score with final destination use (heating, cooling, hot water, lighting), rendering the abstract notions of energy more tangible (Shove, 2003)

The nine EPCs under study vary not only in the way they present the information, but even what information they contain and how it is calculated. Therefore, before analysing the framing of the information and the nudges (subsection HOW: the role of nudges), a quick overview will be given to what key information they contain (subsection WHAT is present in the EPCs).

Methodology of the focus group

The second phase of research following the comparative analysis of the EPCs was a focus group with seven experts with technical or social background from Flanders. The focus group had the aim to analyse the findings from the comparative analysis and select the information framings and the nudges to be tested in a later stage with dwellers in a quantitative way.

The selection of participants had the purpose to complement the knowledge in energy performance, with knowledge in behaviour, which led to a productive discussion and even debate. Among the participants were: two EPC certifiers; an expert in energy simulations and EPC certifier; a PhD student specialised in the energy efficiency of dwellings; an energy adviser working in an NGO; two experts in behaviour. The focus group was moderated by a researcher from the university. Five out of seven participants have direct interaction with private and social housing dwellers and shared their experience on the acceptability and impact of the Flemish certificate. The experts in behaviour gave insights on how the information might be perceived by the dwellers and whether biases and heuristics play a role in the interpretation of the information.

The discussion was not limited to the existing version of the Flemish EPC, but looked at the alternative information framings from the nine European EPCs. Therefore, a presentation on the results of the comparative analysis accompanied the discussion. The discussion had the following structure:

- the effectiveness of the existing Flemish EPC based on the experience of the certifiers and energy experts with the dwellers;
- information framings of the energy performance indicator and of the recommendations: the array of possible information framings derived from the comparative analysis (see *Table 20* and *Table 21*);
- possible biases in the interpretation of the existing version of the Flemish EPC and potential nudges for encouraging the uptake of the recommendations;

The main findings of the focus group are detailed in Main findings of the focus group. The focus group is a qualitative method and its findings cannot be generalized. Nevertheless, it allowed to have an in depth discussion with experts with complementing expertise: in energy performance on one hand and in behavioural insights on the other hand. It resulted in a confrontation of visions and new insights.

Main findings of the comparative analysis

WHAT is present in the EPCs

The EU Directive 2010/31/EU(EC, 2002) allows freedom in the definition of the energy performance indicator. Most countries opted for an energy label that resembles the appliances label, while Flanders opted for a continuous scale (*Figure 7*) and Germany for both, (*Table 20*). The units are mainly kWh/m^2 per year of primary energy, while the UK indicator is the reverse: unitless energy efficiency. The main label of Spain represents the CO_2 emissions, while other countries added a secondary indicator for the environmental impact (the UK, France, Lombardy and Flanders). Romania opted to add specific labels for heating, hot water, lighting, cooling and mechanical ventilation, besides the global label. This is a good example of making salient the final use of the energy, in order to avoid representing energy in an abstract way. Nevertheless, this could lead to the misinterpretation that the information on the EPC is personalized, while it is calculated for a standard occupancy.

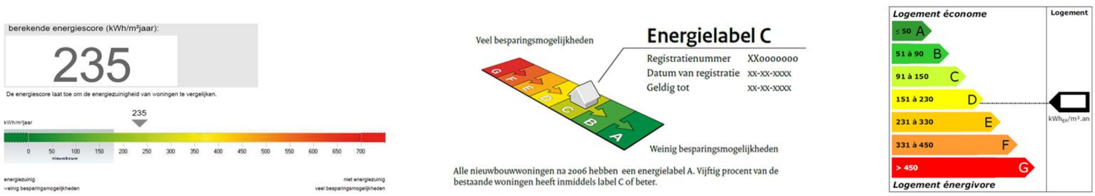

Figure 7 Energy performance indicators of the EPCs. From left to right: Flanders (score and continuous scale), the Netherlands and France (labels)

Similarly, the certificates that include the photo of the dwelling (Germany, Spain, Denmark and Flanders) might use it as a affect heuristic to avoid analysing the technical information about energy performance, being more influenced by the aesthetics of the dwelling (Zajonc, 1980). Few EPCs contain the site plan, only the certificate of Spain and Lombardy, but it might be practical to have it when considering the placement of certain measures such as PV panels or geothermal heat pumps.

Table 20 Overview of the information present on the EPCs

		DE	NL	UK	ES	RO	DK	FR	Lombar-dy	Flanders
Number of pages		5	1	4	7	6	14	4	2	5
Online version		-	✓	✓	-	-	✓	-	✓	-
Photo of the dwelling		✓	-	-	✓	-	✓	-	-	✓
Site plan		-	-	-	✓	-	-	-	✓	-
Energy rating	Label	✓	✓	✓	✓	✓	✓	✓	✓	-
	Scale	✓	-	-	-	-	-	-	-	✓
	Type of indicator	primary energy	-	EE	CO_2	final energy	-	primary energy	primary energy	primary energy
	Units	kWh/m² per year	-	-	kg CO_2/m² per year	kWh/m² per year	-	kWh/m² per year	kWh/m² per year	kWh/m² per year
CO_2 emissions label/ scale		-	-	✓	✓	-	-	✓	✓	✓
Assessment of recommendations		✓	-	✓	✓	-	✓	✓	✓	-

HOW: the role of nudges

Difficult to process information contributes to a system 1 thinking and first degree nudges aim a rational processing of this information. Yet, many of the certificates, such as the ones of Flanders and Germany, seem to be addressing experts with technical terms such as U-value, primary energy and kWh/m² per year. The certificates from the UK, France, Lombard region have 'translated' technical terms and concepts into self-explanatory content or images. Besides, changes have been made in order to avoid overload of information and to render the key information more salient.

One of the key messages of the EPC is the energy performance of the dwelling compared to the rest of the building stock. If the first degree nudges aim to avoid existing biases, the second degree nudges use them towards a predictable outcome. "*Fifty percent of existing homes are now labelled C or better*" placed under the Dutch label exploits the social norm bias.

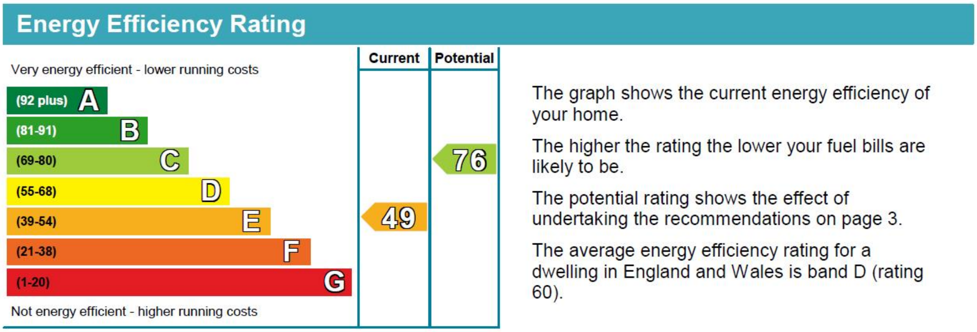

Figure 8 Energy performance label of the EPC of the UK. Anchoring nudge – the potential energy class of the label

The third degree nudges consist in inducing a new bias. The anchoring heuristic consists in using a reference and adjusting it for an estimation (Tversky and Kahneman, 1974). Yet the adjustment is often not sufficient and the final estimation depends on the initial reference, that acts as an anchor. This nudge can provide a reference for the house owner in evaluating the energy performance of the dwelling. In the case of Flanders, the reference provided is the grey shaded area of the scale in reference to the new construction standard ('nieuwbouw'), see *Figure 11*. Also the UK energy label contains the potential energy class achieved after undertaking the recommended measures that might work as an anchor (*Figure 8*).

The second important aspect of the EPC is to show the potential savings of the recommended energy efficiency measures. Flanders, the Netherlands and Romania chose not to illustrate the impact of the recommendations compared to the current energy performance of the dwelling. The rest of the EPCs contain a variety of possible ways both in content and in presentation. Most of them opted for a table (*Figure 9*), making the recommended measures more salient and easier to compare. The illustration of savings vary also in terms: whether by estimating energy savings (Spain), monetary savings (the UK), CO_2 reduction (France) or the cost per tonne of CO_2 saved (Denmark), see *Table 20*. These estimations have to be coherent with the units used in the label: monetary or environmental. Both have advantages and disadvantages, but it is important to use only one of the two languages, because using extrinsic (monetary) and intrinsic (environmental) motivations at once might weaken the message (Schwartz et al., 2015).

Top actions you can take to save money and make your home more efficient			
Recommended measures	**Indicative cost**	**Typical savings over 3 years**	**Available with Green Deal**
1 Increase loft insulation to 270 mm	£100 - £350	£141	✓
2 Cavity wall insulation	£500 - £1,500	£537	✓
3 Draught proofing	£80 - £120	£78	✓

Figure 9 Table with energy efficiency recommendations, EPC of the UK. Nudge - discounting the future

For the UK certificate (*Figure 9*), changes have been made, showing the savings of the recommended measures over three years instead of five years (BIT, 2011b). By illustrating savings over a shorter span of time, it was taken into account the hyperbolic discounting (temporal discounting or present bias).

Yet not all nudges regard information framing, an effective nudge is the automatic inscription to informational campaigns or to the online database of EPCs (the UK, the Netherlands), with the possibility to opt out (default nudge). Some countries opted for a shorter version of the paper certificate, with more extensive information available online (Denmark, the UK).

Table 21 Overview of units for energy-efficiency recommended measures

	Unit	**Assessment of the measure**	**DE**	**NL**	**UK**	**ES**	**RO**	**DK**	**FR**	**Lom-bardy**	**Flan-ders**
Monetary	£	Investment cost, savings			✓						
	€/kWh	Cost per kWh saved	✓								
	pictogram **€**	Investment cost							✓		
	pictogram ★	Savings							✓		
	kr. and tonnes CO_2	Savings						✓			
	years	Payback period	✓								
	pictogram 	Payback period							✓		
Energy	kWh/m^2 per year	Reduction in energy demand				✓					
	%	Reduction in energy demand								✓	
	W/m^2K	Performance (U-value)								✓	✓
	A+ to G	Achieved energy class								✓	
Envi-ronmental	kg CO_2/m^2 per year	Reduction in CO_2 emissions				✓					
	%	Reduction in CO_2 emissions								✓	
	kr. and tonnes	Savings						✓			

	CO_2										
Other	✓	*Single measure/ renovation*	✓								
	m^2	*Surface*								✓	
	high medium low	*Priority of the measure*								✓	

Legend:

Pictogram **€** *more than 200 Euros tax incl.;* **€€** *from 200 to1000 Euros tax incl.;***€€€** *from 1000 to 5000 Euros tax incl.;* **€€€€** *more than 5000 Euros tax incl.*

Pictogram ★ more than 100 € tax incl./ year; ★★ from 100 to 200 € tax incl./ year; ★★★ from 200 to 300 € tax incl./ year; ★★★★ more than 300 € tax incl./ year;

Pictogram more than 5 years, from 5 to 10 years; from 10 to 15 years; more than 15 years

Table 22 Overview of the nudges implied by the EPCs

		DE	NL	UK	ES	RO	DK	FR	Lom-bardy	Flanders
First Degree Nudge	Make it easy	-	✓	✓	-	-	✓	✓	✓	-
	Make it salient	✓	-	✓	-	✓	✓	✓	✓	-
Second Degree Nudge	Social norm	✓	✓	-	-	-	✓	-	-	-
	Temporal discounting	✓	-	✓	✓	-	-	✓	✓	-
	Default	-	✓	✓	-	-	✓	-	-	-
Third Degree Nudge	Anchoring	✓	✓	✓	-	-	✓	-	✓	✓

Main findings of the focus group

Thematic coding

The discussion during the focus group with a duration of two hours was transcribed *ad verbum*. Simultaneously with the transcription process, notes were being taken with potential thematic codes and comments regarding the tone of the voice, etc. Subsequently, out of all the thematic codes, the ones relevant to the research question were selected. The research questions of the focus group were: what is the impact of the existing Flemish EPC and which insights from the comparative analysis can be applied in order to improve it? As a basis for discussion of possible ways of presenting the information served the insights from the comparative analysis of the nine EPCs. Initially the codes were divided in three main themes: 'Impact on the dwellers', 'Experts' perspective' and 'Biases and nudges'. In order to avoid double coding, the biases were integrated in the corresponding codes, for example, 'availability heuristic' was nested under the 'score vs. label', see *Figure 10.*

Results of the focus group

In the following section the main insights from the focus group will be detailed. The content of 'Impact on the dwellers' resulted from the reporting of practitioners such as EPC certifiers and energy advisers on their interaction with the dwellers. Only certain findings of the comparative analysis were presented to the experts: the possible framing of the information in terms of units (*Table 20* and *Table 21*). The findings regarding the possible nudges were not presented to avoid influence on the discussion. Since some experts were not familiar with the terms of the behavioural economics, some definitions and examples of biases were given. *Figure 10* lists possible biases and nudges emerged from the focus group discussion and these are different from the ones of the comparative analysis, see *Table 22*.

1. Impact on the dwellers – trust in the EPC

Participants agreed that the existing version of the Flemish EPC is not regarded as a reliable and trustable source of information. It was recalled bad coverage in media that worsened the trust of the dwellers.

"... the house owners say:" you cannot trust the EPC number that you get, because there's so much dependence on who is calculating it"..." (policy maker)

Energy advisers and EPC certifiers affirmed that many dwellers do not read the certificate beyond the first page (the recommendations are listed on the third page) and some dwellers are not even aware of having it. Many experts mentioned that often house-owners perceive the certificate as a bureaucratic burden and an obligation to comply with, not as a source of information.

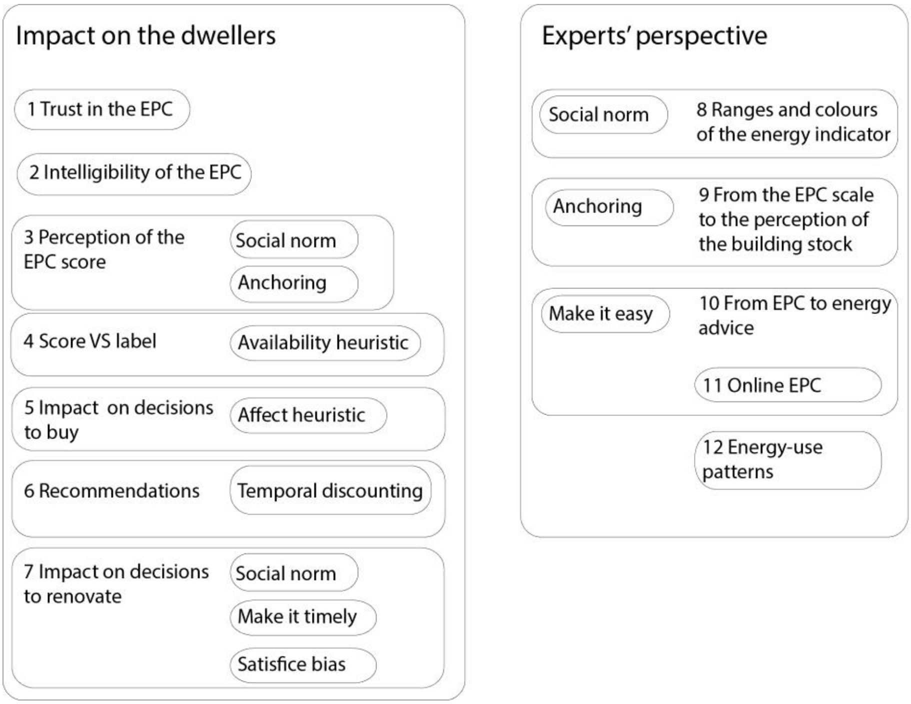

Figure 10 Overview of the themes and codes

2. Impact on the dwellers – intelligibility of the EPC

In several occasions the technical language that is beyond the level of expertise of the dwellers was mentioned. Regarding the EPC score, that is expressed in kWh/m^2 per year, most of the experts agreed that dwellers ignore the units and consider only the number.

"...the EPC it's becoming something like a fashion label."

"what's your EPC?, what's my EPC, people are benchmarking the figure without knowing what it actually means" (EPC certifier)

It was underlined that the dwellers are not able to make sense of the information on the EPC on their own and they need professional assistance. The difficulty to understand the information presented might influence the lack of interest in the certificate nowadays.

3. Impact on the dwellers – perception of the EPC score. Biases and nudges – social norm and anchoring.

On the first page of the certificate, besides the address of the dwelling and of the certifying company, there is only the photo of the dwelling and the energy performance indicator. As a reference for the discussion served a certificate of a typical Flemish terraced house with the EPC score of 235 kWh/m^2 per year (*Figure 11*). The energy performance score is illustrated on a coloured gradient scale from green to red and 235 is situated on the limit between green and yellow. According to the participants, the colours of the scale play an important role in assessing the energy performance of the dwelling.

"It's like traffic lights: red is bad, green is good" (expert in behaviour, social housing)

Since the EPC score represents the yearly primary energy per square meter, it was pointed out by some experts that the dwellers do not perceive the effect of the size of the dwelling. The total amount of primary energy needed is shown only on the second page of the certificate, as plain text.

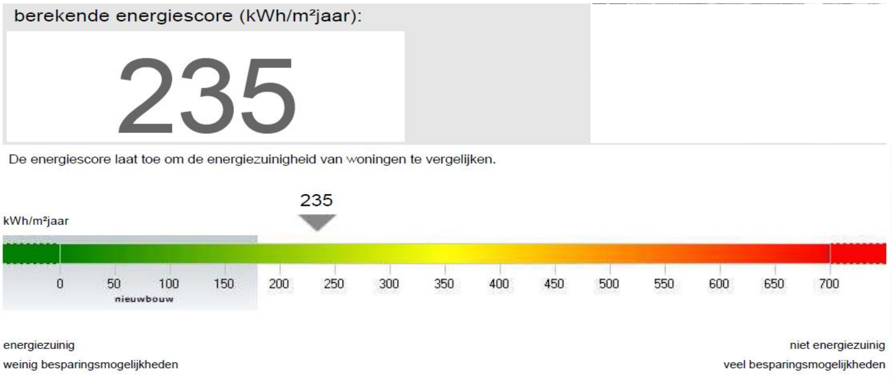

Figure 11 Energy performance indicator of the Flemish EPC: energy score and continuous scale

It was argued that the dwellers should be aware of the total energy consumption in order to consider it in their decision making, therefore this number should be visible in the main energy performance indicator. On the other hand, other experts consider that having the unit kWh/m^2 renders the dwellings comparable in terms of energy efficiency.

4. Impact on the dwellers – score vs. label. Biases – availability heuristic.

All the certificates analysed contain a label as the energy performance indicator, the Flemish being the only one with a score, see *Figure 7* and *Table 20*.

The participants agreed that the label is "*more familiar*" and "*it speaks more*", because it resembles the label used for appliances. The label could be more effective because of an aspect of the availability heuristic (Kahneman et al., 1982) that is the retrievability bias – the ease with which it can be recalled since it is already present in the memory (Tversky and Kahneman, 1974). Nevertheless, some experts mentioned the risk that house owners would be prone to influence the EPC certifier when the score is at the limit between two classes. Others argued that this risk, if present, could persist also with the score.

5. Impact on the dwellers – impact on decision to buy. Biases – affect heuristic.

While purchasing the house, rather than being cold-minded and take into account the energy performance stated in the EPC, people are influenced by their emotions, denoting an affect heuristic.

"...most people choose with their hearts and their feeling" expert in energy

At the same time, the certificate is *"too technical"*, which impedes to assess the overall energy performance due to cognitive load. Instead, people pay more attention to visible aspects of the dwelling, such as *"is there single glass? does it look new?".* This might contribute to a heuristic purchase decision making.

6. Impact on the dwellers–recommendations. Biases and nudges – temporal discounting.

The following is an example extrapolated from the list of recommendations (translated from Dutch): *"58.5 m² of the roof is not insulated... An energy-efficient roof has a U-value lower than 0.4 W/m²K".* The participants have underlined that the existing recommendations are rather generic and obvious.

"If there's no insulation, you have to put insulation on your roof", OK, that's nothing new." Energy adviser, NGO

Besides being standard measures, these are presented in technical terms. The properties of the new element (U-value) are stated without comparing the performance after installing it with the current situation. *Figure 9* illustrates an example of such comparative table of the recommendations. Unlike the Flemish certificate, most of the European EPCs provide similar tables with the eventual energy savings, CO_2 savings and other information such as investment costs, availability of funding, etc., see *Table 21*.

Yet, the participants of the focus group pointed out that most of the measures have a long payback time of around 30 years. The benefits over such a long time span are faded out due to temporal discounting. Therefore, showing the benefits of the renovation only in terms of monetary savings would be have a lower impact than expected. On the other hand, other benefits of the renovation such an improved comfort are difficult to quantify in a standardized way.

If the measures are not standard, a personalized energy advice is required, which would imply higher costs. Therefore, there is a trade-off between the quality and the price of the certificate.

7. Impact on the dwellers – impact on decisions to renovate. Biases and nudges – social norm, make it timely, satisfice bias.

Both the energy performance indicator and the recommendations could encourage the dwellers to look for more energy advice and eventually renovate. Nevertheless:

"Only if the number is really, really bad, people start looking at the recommendations. …

I think when the number is green or yellow, nobody really cares about the recommendations." EPC certifier

The current wide ranges of green and yellow give the impression of "*false feeling of doing slightly better*" than the rest. The satisfice bias (Simon, 1955) – opting for the 'good enough' rather than 'the best' might "*temper thorough investments and create the lock in*". Another aspect is the moment of receiving the certificate with the recommendations, when *"most of your money is gone".* The social norm of *"X per cent of people buying houses with this label refurbished within the next 3 years"* was suggested as a nudge.

8. Experts' perspective: ranges and colours of the EPC indicator. Biases and nudges: social norm. 9. Experts' perspective: from the EPC scale to the perception of the existing building stock. Biases and nudges: anchoring.

The experts with a technical background stated that the EPC score presented as an example, 235 kWh/m^2 per year, is actually too high to be in the green-yellow area of the scale, see *Figure 11*. Some of them proposed to assign the green colour ranges up to 100 kWh/m^2. In this way, the example of 235 kWh/m^2 would be in red or yellow-red spectrum, instead of the current yellow-green area. Other participants, mostly with the social sciences background, opposed rescaling, considering that it would mean shifting 90 per cent of the existing dwellings on the market in the red area. This impression about the energy performance of the existing building stock might be emphasized by the outdated reference 'new construction' that suggests that very few existing buildings are situated in the green area. *Figure 13* shows that 20 per cent of the existing dwellings score better than 200 kWh/m^2. Therefore the performance of the rest of the dwelling stock might be underestimated, contributing to an optimistic evaluation of the EPC score of ones dwelling.

10. Experts' perspective – from EPC to energy advice. Nudge – make it easy. 11. Online EPC. 12. Energy-use patterns.

A recurrent topic during the discussion was the standard occupancy input of the calculations, which does not reflect the actual energy-use patterns of the dwellers. This translates into generic recommendations that do not show the full potential of the energy efficiency measures. An online tool was suggested, that would incorporate the energy usage patterns. The tool would also facilitate energy simulations for architects and other energy advisors. An important aspect is the link from the certificate to the online tool, via a QR code, in order to remove the barriers and frictions for an action, known as 'make it easy' nudge.

Discussion

The focus group discussions have pointed out repeatedly the need to integrate the user patterns into the EPC, whether it is online or on paper. It would imply an energy screening and advice that goes beyond the existing default values and standard recommendations. As other reports point out, there is a trade-off between the quality and the cost of the certificate (Sutherland et al., 2015). Thus there is the need for a better definition of the purpose of the Flemish EPC. Is it only a first insight on the energy performance as in the Netherlands or a detailed energy advice as in Denmark? For now, many EPCs, including the Flemish, are half way between the two models and mislead the expectations of both dwellers and policy makers.

The paper version of the Flemish EPC presents a limited number of generic recommendations that could be complemented with an online tool. A new voluntary policy tool is under development, the building passport (Fabbri et al., 2016). Besides the inclusion of user patterns, a long term roadmap for the energy renovation of the dwelling will be provided. Since the EPC is compulsory, it should work as a 'bridge' towards the building passport. During the focus group, is was suggested that the online tool could be accessed via a QR or bar code directly from the paper version of the EPC. This nudge, 'make it easy', reduces the frictional, extra hassle of undertaking an action (Hallsworth et al., 2014).

The dwellers might be likely to undertake further personalized energy advice if the certificate will show the energy performance and its potential in a clear and convincing way. Since the focus group provided clues that the EPC score and the coloured scale has the biggest impact, its rescale has to be considered. According to the Flemish EPC, a dwelling with the energy score of 235 kWh/m^2 per year of primary energy is on the green-yellow part of the scale, while on the German EPC it is on red part of the scale (*Figure 12*).

At the European level, due to differences in climatic conditions and building typologies, common guidelines regarding the ranges of scale cannot be provided in absolute terms, such as kWh/m^2 per year. These ranges of the colour gradients must be adjusted for each member state according to:

- the energy performance of the existing building stock
- the minimum requirements for the new construction
- the policy targets

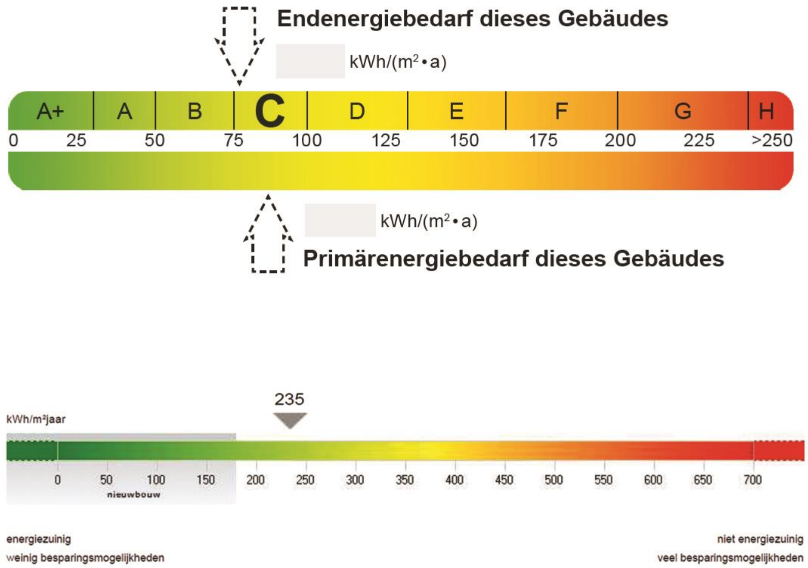

Figure 12 The scales of the energy performance certificates. Upper - EPC of Germany, lower - EPC of Flanders

In the case of Flanders, if the continuous scale of the EPC is overlapped with graph of the distribution of the dwellings according to the EPC score (Verbeeck and Ceulemans, 2015), *Figure 13*, the following can be derived:

- The green area (less than 100 kWh/m^2 per year) includes 1 per cent of the dwellings
- The green-yellow (from 100 to 300 kWh/m^2 per year) – 40 per cent of the dwellings
- The yellow area (from 300 to 400 kWh/m^2 per year) – 16 per cent of the dwellings
- The yellow-red area (from 400 to 600 kWh/m^2 per year) – 25 per cent of the dwellings

- The red area (more than 600 kWh/m^2 per year) – 18 per cent of the dwellings

The above data represent the existing dwellings from Flanders that received an EPC certification by 2012. The data does not include the new constructions that require EPB certificates, therefore the existing dwellings on the market perform even better. 57 per cent of the existing dwellings have energy scores situated in the green, yellow-green and yellow areas of the scale. The experts agreed that if a house owner receives a certificate with green or yellow scores, most likely he will not look for further energy advice.

During the focus group there was a debate between experts with technical background, who urged to rescale the colour gradients. On the other hand, participants lacking knowledge in energy performance, were against rescaling. Possibly due to an illusion of a normal distribution of the existing dwellings according to the energy performance score if overlapped on the EPC scale, while in fact it is right skewed, see *Figure 13*. They argued that a rescaling of the colour gradients would imply that the majority of the existing dwelling would be in the red area of the scale, losing the sensitivity of comparison. This illusion of a normal distribution might be caused also by the outdated value of the 'new construction' of 180 kWh/m^2. The minimum value required for the new construction in 2016 is E50 (around 80 kWh/m^2) and it is gradually getting lower. As the focus group discussion revealed, it might give the house owner the false impression of having a better energy performance of his dwelling by underestimating the performance of the rest of the building stock. This bias has to be further validated with experiments with dwellers. If confirmed, a rescaling of the EPC scale or its colour gradients would be necessary.

An alternative to the rescaling would be a social norm nudge. In the case of a normal distribution, the mean and the median are the same, while in a right skewed graph the mean is higher because of the outliers. Representing the median instead of the mean is advisable –"*50* per cent *of the dwellings score less than X*", where X is the median. It is important to verify experimentally whether the nudges are effective enough and compare it to the effect of rescaling the ranges of the scale.

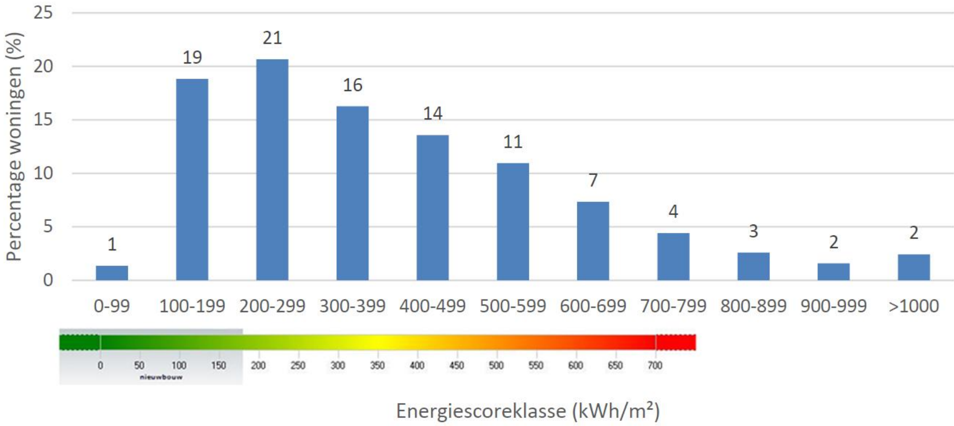

Figure 13 Distribution of the dwellings according to the EPC score (Verbeeck and Ceulemans 2015) and the scale of the energy performance indicator of the Flemish EPC. Data from 2012

The previous analysis concerns comparing the EPC score in relative terms to the rest of the Flemish building stock. Yet, the dwelling can be compared in absolute terms to an energy efficient dwelling and the scale should reflect the long term policy goals. By 2050 Germany aims for 'best possible principle per dwelling' and an average of 34-40 kWh/m² per year for the existing building stock (Fabbri et al., 2016). The ranges of the scale of the German EPC are in line with this target. Flanders aims for a maximum of 100kWh/m² per year for all the existing dwellings, therefore there is the need to rescale the ranges of the energy performance indicator. Besides, the 'new construction' reference has to be updated to the present minimum requirements.

Conclusions

Even though the EPC is regarded as a key policy instrument in promoting energy efficiency in the residential sector, so far its impact on the purchase and rental decisions is quite limited (Mudgal et al., 2013) (Christensen et al., 2014). The undertaken qualitative analysis points out that information framing is an important aspect in the implementation of the EPC, alongside quality control in the calculation software and training of the energy experts. The bounded rationality and the system 1 thinking have to be taken into account in the elaboration of the certificate. Even though the existence of the biases listed in *Figure 10* and *Table 22* is supported by studies in other field of policy making, its application to the energy context is yet to be investigated. The next stage of our research will be to test the insights from the comparative analysis and the focus group with experiments with dwellers.

The comparative analysis revealed a wide range of possible information framings, for illustrating the key messages and the technical concepts of the certificate. Each member state has to define a priori what is the purpose of the EPC. There are two possible purposes, that will influence the length, the content and the layout of the certificate. Is it a first insight into the current situation of the dwelling and its potential, with generic recommendations or is it a detailed and tailored energy advice? Certain EPCs, including the Flemish, are at half way between the two models and contain a lot of technical specifications, even though the recommendations provided are rather standard and generic. It is important to notice that there is the trade-off between the cost and the quality of the recommendations.

At the same time, Germany, France and the Region of Flanders are developing a new policy instrument, the building renovation passport (Fabbri et al., 2016). It aims to provide a roadmap of a renovation process in phases, with personalised and detailed energy advice. If the existing EPC scheme is compulsory, the building passport will be a voluntary scheme (Fabbri et al., 2016). If the purpose of the EPC is to be a 'bridge' towards the building passport, encouraging the house owner to seek for further energy advice, it is important that it gives a clear first assessment of the current and potential energy performance of the dwelling. This underlines even more the necessity to test whether the information presented to the dwellers is perceived as it is intended, without biases.

The comparative analysis and the focus group indicate that the existing energy performance indicator of the Flemish certificate might contribute to an unjustified optimistic appreciation of the energy performance of the dwelling. The factors contributing are: the range of the scale up to 700kWh/m^2, the wide spectrum of the green and yellow colours and the outdated reference value of the 'new construction'. It is important to verify experimentally whether the energy performance indicator gives an accurate understanding of the energy performance of the dwelling in comparison with the rest of the building stock. At the European level, common guidelines regarding the ranges energy performance indicator can be provided relative to specifics of the members state: the energy performance of existing building stock, the minimum requirements for the new construction and the policy targets for 2050.

Another important aspect is the choice of the units for the energy performance indicator, as well as for the recommendations. The comparative analysis revealed a wide range of units, denoting energy consumption, energy efficiency, CO_2 emissions, monetary savings or even unitless. Whether these are monetary or environmental can contribute to extrinsic or intrinsic motivations to undertake the recommended energy efficiency measures.

The existing heterogeneity of the European EPCs provides us with a rich variety of possibilities whose efficacy can be compared and tested. This qualitative analysis gives an overview of various approaches at European level, as well as more concrete biases and nudges to be tested experimentally for the Flemish EPC. No message is neutral and even if nudging is not a purpose, the heuristic thinking might influence the understanding of the energy performance and of the potential of the dwelling. These are the first steps and further research is needed in order to provide guidelines at the EU level in order to render the EPC an effective communication tool with the dwellers.

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Chapter 4

Upgrading the energy label for dwellings – example of a behaviourally-informed policy tool[5]

Abstract

The energy performance certificate (EPC) is mandatory in the EU, aiming to enable prospective buyers and renters to compare dwellings in terms of energy performance. Flanders intends to improve its current EPC, by adding a label to the existing coloured scale and EPC score. Our research aimed to inform the Flemish Energy Agency by testing before releasing the new version of the certificate, thus being an example of behaviourally-informed policies.

Firstly, a literature review of experiments on information framing in similar contexts is presented. Given the evidence of the importance of information framing, we tested ten versions of the new label (N= 224). Nudges used included social norm, anchoring and rescaling. Dependent variables were perceived energy efficiency, energy consumption and estimated percentage of Flemish dwellings with a better label. Besides, we tested whether respondents are aware that the label is relative to the dwelling size. Based on these results the label was rescaled, from the initial G to A, to F to A+. Rescaling corrects the overoptimistic assessment of the energy performance label F compared to the rest of the dwelling stock. Another finding is that presenting information as bar graph is more effective than plain text.

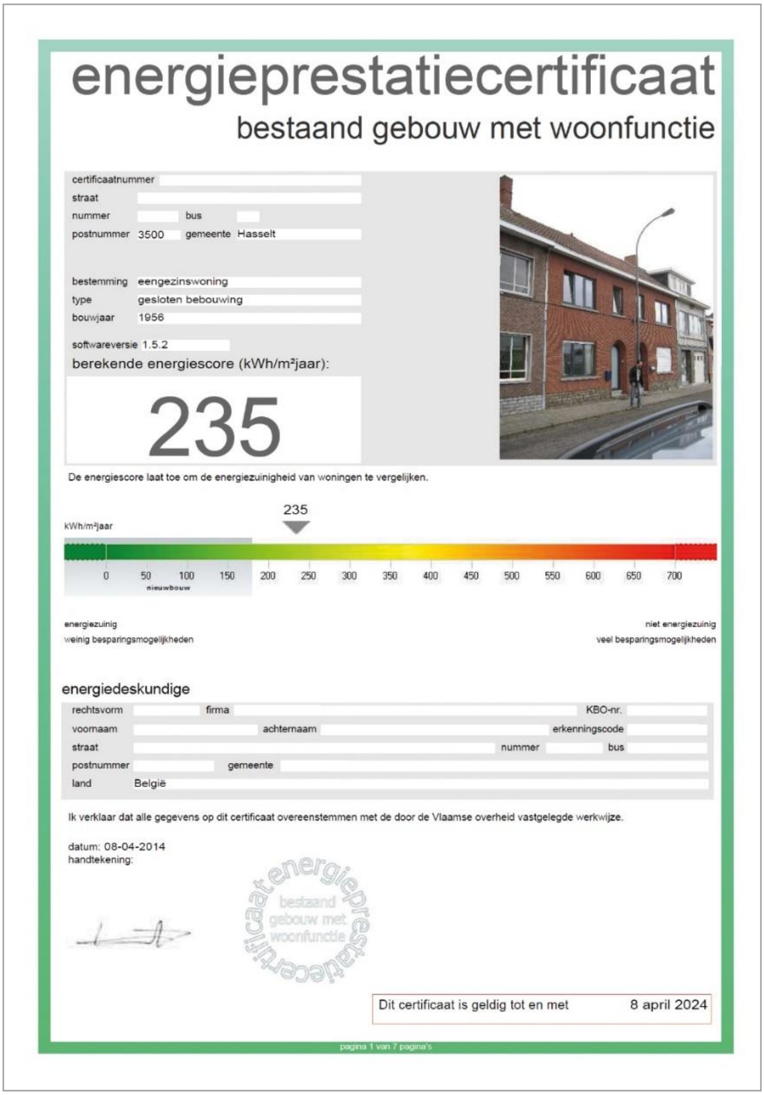
[5] The present chapter is based on the article "*Energy performance label in Flanders – an example of behaviourally-informed policy tool*" by Taranu Victoria, Verbeeck Griet & Nuyts Erik to be submitted to the Journal Energy Policy.

Introduction

One of the information provision tools to promote energy efficiency (EE) in the residential sector is the energy performance certificate (EPC). After its introduction with the 2002/91/EC Directive (EC, 2002) and reinforcement with the 2010/31/EU recast (EC, 2010), it is now mandatory in the EU member states at the moment of sale or lending of the property. Firstly, the certificate enables prospective buyers and renters to assess and compare dwellings in terms of their energy performance and to encourage them to take into account the energy performance of the property, alongside other attributes. Secondly, it aims to show the potential to improve the EE of the dwelling by presenting a set of renovation measures. In the EU countries, literature shows mixed results or limited influence of the EPC on the price of selling and renting (Christensen et al., 2014, Mudgal et al., 2013, Wahlstrom, 2016, Harsman et al., 2016), as well as on energy renovation decisions (Christensen et al., 2014, Wade and Eyre, 2015).

In Flanders (Belgium) the EPC scheme came into force in November 2008 for residential buildings for sale, in January 2009 for residential buildings for rental (Mudgal et al., 2013) and in later instances for public and non-residential buildings. The certificate contains an energy indicator, recommendations for improving its EE and other technical information. The present paper will focus on the Flemish EPC scheme for the residential sector, particularly on the first page containing the energy indicator. The version of the certificate that is in use in Flanders since 2008 (see *Figure 14*) will be substituted in January 2019 with a new version that at the moment of the study was a preliminary version still under trial (see *Figure 15*). Based on research, including the present one, the version that will be launched in January 2019 has been changed, compared to the preliminary test version, see *Figure 16* (Vlaamse overheid, 2018).

The original EPC version (in use since 2008) has the following characteristics. While most of the EU certificates contain a label, the Flemish certificate contains an EPC score and a continuous scale.


energieprestatiecertificaat

bestaand gebouw met woonfunctie

certificaatnummer
straat
nummer bus
postnummer 3500 gemeente Hasselt

bestemming eengezinswoning
type gesloten bebouwing
bouwjaar 1956

softwareversie 1.5.2

berekende energiescore (kWh/m²jaar):

235

De energiescore laat toe om de energiezuinigheid van woningen te vergelijken.

235

kWh/m²jaar

0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

nieuwbouw

energiezuinig
weinig besparingsmogelijkheden

niet energiezuinig
veel besparingsmogelijkheden

energiedeskundige

rechtsvorm firma KBO-nr.
voornaam achternaam erkenningscode
straat nummer bus
postnummer gemeente
land België

Ik verklaar dat alle gegevens op dit certificaat overeenstemmen met de door de Vlaamse overheid vastgelegde werkwijze.

datum: 08-04-2014
handtekening:

energieprestatiecertificaat bestaand gebouw met woonfunctie

Dit certificaat is geldig tot en met 8 april 2024

pagina 1 van 7 pagina's

Figure 14 First page of the existing version of the Flemish EPC in use until end of 2018. The energy performance indicator consists of an EPC score and a continuous scale.

The scale is ranging from -100 to 800 kWh/m² per year of primary energy, even though the extremes are not specified, the last specified being 0 and 700 kWh/m² per year (coloured bar on *Figure 14*). Primary energy use includes a factor to convert actual energy use into overall fossil energy use which varies according to the fuel used in the dwelling. The energy performance indicator is relative to the size of the dwelling (expressed as kWh per m^2 of floor area) and it is calculated for standard occupancy and standard Belgian climate. The total primary energy is also presented on the certificate, but only on the second page of the certificate and in a less salient way. The preliminary test version has several changes compared to the existing EPC, the main being the addition of the label besides the EPC score and the scale, see *Figure 15*. The scale is inverted compared to the previous version and ranges from 700 to 0 kWh/m^2 per year of primary energy, last specified being 600 and 100 kWh/m^2 per year.

In Flanders there is evidence of the impact, even though limited, of the certificate on market – properties with 1 per cent higher EPC score have 0.075 per cent lower sales price (Agentschap Innoveren & Ondernemen, 2016). According to the experts involved in iBROAD project conducted by BPIE (BPIE, 2018) prospective buyers use the certificate to negotiate the price. On the other hand, the experts of the iBROAD project and of our focus group, see *Chapter 3*, agree that the certificate is not regarded as a trustful source of information, particularly regarding renovation advice. The information is not presented in a salient way and it contains technical terms difficult to interpret. There is a range of factors that might influence the efficacy of the EPC as an information provision tool. Up to now, the supervision of the implementation at European level has mainly focused on the compliance, quality assurance and training of the certifiers (Arcipowska et al., 2014, Maivel et al., 2016). Few projects and reports analyse the importance of the content and layout (IDEAL EPBD Project, Sutherland et al., 2015), underlining limited research in this regard and the need for further research. In order to have the expected impact, the certificate must be elaborated in such way as to overcome individual market failures – bounded rationality and bounded will power (Bubb and Pildes, 2014).

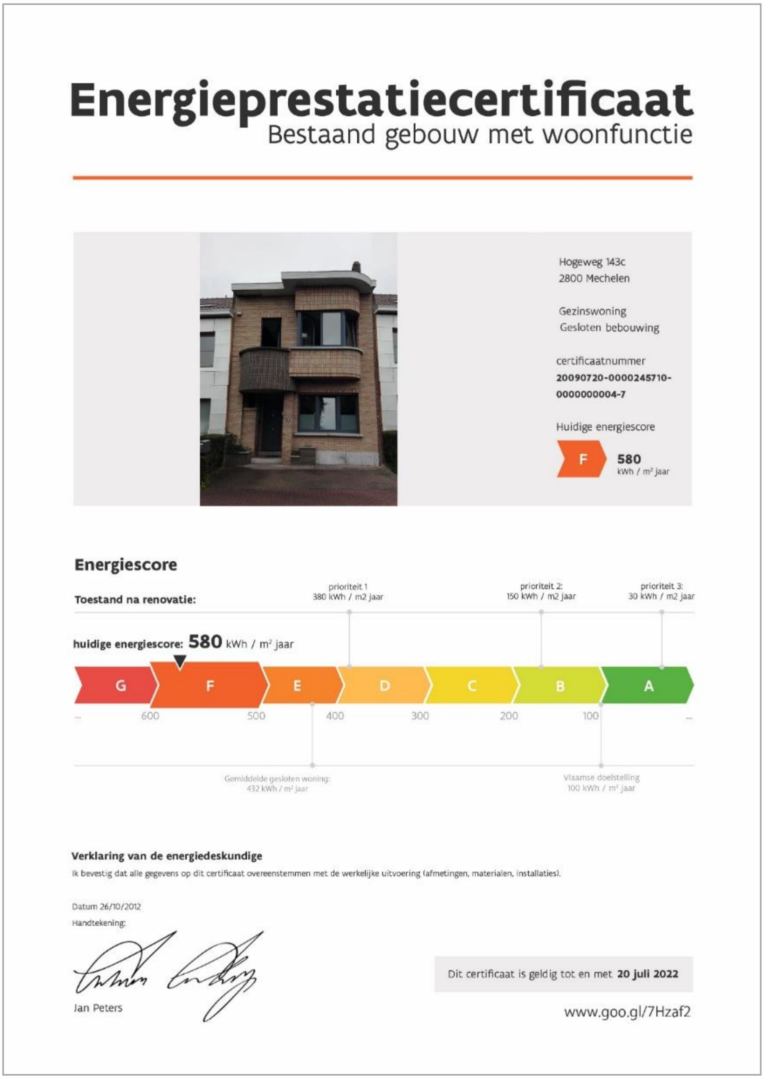


Figure 15 New version of the Flemish EPC. The energy performance indicator consists of an EPC score, a label placed on a continuous scale.

The hypothesis of our research is that the framing of the information plays a role in how people comprehend and interpret the preliminary new version of the Flemish energy label. A wrong interpretation of the label could mean a distorted estimation of the energy performance of a dwelling compared to the rest of the dwellings on the market that could indirectly impact the purchase, rental or renovation decisions. Eventually it might influence the effectiveness of the EPC as a policy tool.

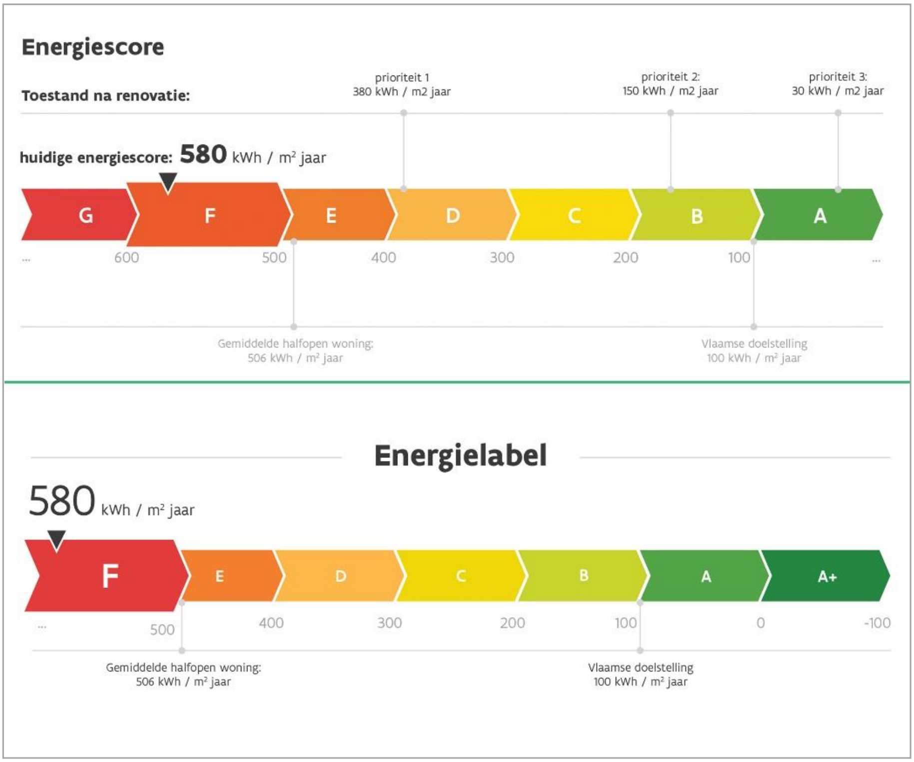


Figure 16 Upper - preliminary energy label (control condition for the study). Lower - final energy label of the Flemish EPC after the study.

Previous research has shown evidence of biased interpretation of energy metrics, such as the perceived linearity of MPG (Larrick and Soll, 2008, Larrick et al., 2015). Another example regards the energy label of the appliances, the 'energy efficiency fallacy', when consumers focus only on the energy efficiency (e.g. class A), ignoring the information about annual electricity consumption (e.g., 100 kWh/year) (Waechter et al., 2015b). This biased interpretation of the information on the energy labels might contribute to sub-optimal decision making for consumers and ineffective information provision tools. Therefore it is crucial to verify the interpretation of various information framings of new versions of the EPC.

By information framing we intend the following aspects: the content, the wording and the layout. We do not analyse these aspects separately because in the case of the energy indicator, the choice between EPC score and label implies changes in all these three aspects at once, see *Figure 14* and *Figure 15*. Information framing does not equal, but includes framing effects: the decisions of people are affected by the wording of the same message, for example in positive or negative terms (Kahneman and Tversky, 1979). In the same line, various dual-process models state that a message can be processed in a heuristic or in a deliberative way – system 1/system 2 thinking (Evans and Frankish, 2013).

The current paper presents the results of an experimental study (N=225) comparing ten alternative information framings of the energy indicator. The aim is to investigate if respondents are prone to biases and if certain nudges are effective in correcting them. In this context biases mean cognitive errors in interpreting information, for example an optimistic estimation of the dwellings in the red spectrum due to the illusion of a uniform distribution of the existing dwellings on the scale, see label 2.1 and 2.2 of *Figure 17*. At the same time, biases mean shortcuts to deliberative thinking, for example using social norm or anchoring to avoid effortful system 2 thinking. The second type of biases, if used in the right direction, become nudges that could correct the first type of cognitive biases. Based on a qualitative previous study (Taranu and Verbeeck, 2017), the nudges tested are social norm, anchoring, range effects and salience.

The present paper is structured as follows: the first section provides a literature review of experiments regarding information framings in energy related contexts. It will be followed by the presentation of the experimental study on 10 versions of the energy label of the Flemish EPC. The hypotheses are presented with a theoretical framework of the underpinning behavioural insights. The hypotheses are the result of a previous qualitative study that is explained in more detail in the paper (Taranu and Verbeeck, 2017). The presentation of the experimental study on 10 versions of the energy label of the Flemish EPC follows. In the section Methodology are detailed the method for data collection and data analysis, followed by the presentation of the main findings of the experiments. Based on these results the label of the new version of the Flemish EPC was modified compared to the preliminary version, see *Figure 16*. Wider implications of the study on policy making will be discussed in the Conclusions section.

Importance of information framing in energy label schemes

This section provides a theoretical background for the quantitative experimental study. The first subsection is a literature review of experimental studies regarding information framing in energy related contexts, such as energy labels for appliances, water heaters and vehicles. The second subsection focuses on the EPC scheme – it presents the main findings of the comparative analysis of nine European EPCs under the lenses of behavioural insights and a focus group with experts regarding the Flemish certificate. These findings were the basis for the hypotheses of the experimental study.

Literature review of experimental studies

The EPC includes various messages regarding energy performance that have to be communicated and 'translated' to the dwellers. These messages can be illustrated with various metrics such as kWh/m^2 per year, U-value, CO_2 savings, pictograms, unitless, etc. Evidence shows that the choice of the units, the wording and the layout of these indicators has an impact on how the information is processed. This section gathers a literature review on experiments that test various information framings in energy related contexts and take into account system 1 thinking, see *Table 23*. It is not an exhaustive literature review, but a compilation of experimental studies in similar contexts - labels for appliances, water heaters and vehicles. All the studies take into account the existence of biases and heuristics in the interpretation of the label.

Table 23 Overview of studies of information framing effects in energy related contexts

Reference	***Context***	***Method***	***Sample***	***Behavioural insights***
(Waechter et al., 2015b)	*Energy labels appliances*	*Online experiment*	*169*	*'Energy efficiency fallacy'.*
(Waechter et al., 2015a)	*Energy labels appliances*	*Eye tracking experiment*	*117*	*Bounded rationality.* *'Energy efficiency fallacy'.*
(Waechter et al., 2016a)	*Energy labels appliances*	*Online experiment*	*Study 1 - 217;* *Study 2 - 330*	*Anchor effect – ranges of the scale*
(Waechter et al., 2016b)	*Energy labels appliances*	*Eye tracking experiment*	*59*	*Bounded rationality*
(Blasch et al., 2016)	*Energy labels appliances*	*Online randomized controlled choice experiments*	*583;* *877;* *1,375*	*Bounded rationality* *Salience*
(Larrick and Soll, 2008)	*Fuel economy labels*	*Study 1 and 2 - experimental studies* *Study 3- online survey*	*Study 1- 77;* *Study 2 - 74;* *Study 3 - 171*	*Linear perception of the metric MPG (miles per gallon)*
(Newell and Siikamaki, 2014, Newell and Siikamaki, 2015)	*US Energy Guide* *water heaters label.*	*Online choice experiments and randomized information treatments*	*1,217*	*Discounting the future.*

First a series of experiments is discussed regarding energy labels of the appliances. One of the studies has detected and validated the 'energy efficiency fallacy' (Waechter et al., 2015b). The main information on the energy label is the EE class (e.g. A+++) and the total annual electricity consumption (e.g. 100 kWh/year). The respondents were faced with one experimental condition that was one of the four combinations of low/high EE and low/high total electricity consumption. They were asked to assess the product in terms of energy friendliness. The EE is relative to the size of the appliance. Therefore, two appliances different in size, should be compared in terms of annual electricity consumption, and not of EE class (Waechter et al., 2015b). Yet, the respondents based their estimations only on the EE class, largely ignoring the annual electricity consumption. This 'energy efficiency fallacy' might be caused by the salience of the energy class and it denotes a heuristic interpretation of the label. These findings were confirmed by experiments with eye-tracking technologies (Waechter et al., 2015a).

The salience effect of the class of the energy label for appliances was confirmed also by the study of Blasch et al. Due to bounded rationality, consumers use a heuristic strategy to solve the optimization problem according to a salient characteristic (price or EE class) (Blasch et al., 2016). Another eye-tracking study has revealed bounded rationality (Waechter et al., 2016b). More specifically, it individuated three decision-making strategies: energy-directed lexicographic, unsystematic lexicographic and unsystematic exhaustive. This example shows that not only separate biases in isolation, but also the way of reasoning can be investigated.

An online study focused on the EE indicator of the appliances label (Waechter et al., 2016a). The experimental conditions were: the original scale (A+++ to D), modified scale (A to G), modified colours and scale (A to G), shortened scale (A to C). The respondents were presented with one experimental condition. They were asked to assess the energy friendliness of two products, that had the highest EE class (e.g. A+++ on the original scale) and the second highest (e.g. A++ on the original scale). The results show that consumers might be perceptible to an anchoring effect. The estimation of the difference in energy friendliness between the two products is affected by the number of classes of the scale, the lowest class working as an anchor. The difference between classes was perceived to be larger for the shorter scales. Besides, the perceived difference is higher for A to G scale compared to A+++ to D scale due to the plus sign. The results suggest the necessity to rescale the existing EE indicator or to eliminate the plus sign.

Besides experiments with energy labels for appliances, similar research has been undertaken regarding US Energy Guide label (Newell and Siikamaki, 2015, Newell and Siikamaki, 2014). This study manipulated various information framings of the water heater labels in order to determine the individual discount rates. Besides the monetary savings, additional information was tested with alternatives such as physical energy use and carbon dioxide emissions. Yet, information on the monetary value of energy savings was the most important guiding element for choosing cost-efficient EE investments (Newell and Siikamaki, 2014).

The well-known study of (Larrick and Soll, 2008), shows that the choice of units, MPG (miles per gallon) instead of gallons used per 10,000 miles, can influence an erroneous understanding of the energy efficiency of vehicles. Due to the illusion of linearity of the MPG indicator, people undervalue the improvements of fuel-inefficient cars and subsequently, their replacement.

Applying behavioural insights to the EPC scheme in the EU and Flanders

The studies on labels for appliances, water heaters and vehicles provide evidence of system 1 thinking in interpreting information regarding EE. These insights are complemented by the outcomes of our previous qualitative study regarding labelling schemes for residential buildings – a comparative analysis of nine European EPCs and a focus group (Taranu and Verbeeck, 2017). The focus group with experts aimed to verify how these insights apply to the Flemish EPC and to narrow down the hypotheses and the experimental conditions for the quantitative study of the present paper.

One of the hypotheses of the experimental study is that dwellers do not interpret correctly the EPC score that is expressed in kWh/m^2 per year of primary energy and that is relative to the size of the dwelling. A dwelling of 300 m^2 labelled C with an EPC score of 230 kWh/m^2 per year sums up in total 69.000 kWh per year. That is more than a 100m^2 dwelling labelled F with an EPC score of 580 kWh/m^2 per year that sums up only 58.000 kWh per year. Respondents had to choose which house has a higher energy bill given that the same family lives in both. Our assumption is that respondents will take into account only the label and the EPC score, ignoring the information regarding the size of the dwelling. We will refer to this bias as '*size effect bias*'. It is similar to the 'energy efficiency fallacy' regarding the energy label for the appliances (Waechter et al., 2015b, Waechter et al., 2015a). In the case of appliances, people also focus only on the energy class, ignoring the size or the power of the appliance.

Table 24 Description of the experimental conditions of the study.

Experimental condition	***Description***	***Behavioural insights***
Energy label 1	*Control condition.* *Scale from 700 to 0.* *References – 3 steps of renovation, EPC score average of same type of dwellings, Flemish policy goal for 2050.*	*Anchoring,* *Social norm,* *Information overload.*
Energy label 2	*Bar graph – percentage of Flemish dwellings corresponding to all the labels.*	*Social norm.* *Salience.*
Energy label 3	*Text – percentage of Flemish dwellings with a better label*	*Anchoring.* *Social norm.*
Energy label 4	*Text – Reference on the scale of the median of the Flemish building stock*	*Anchoring.* *Social norm.*
Energy label 5	*Re-scale from G to A (700 to 0 kWh/m2 per year) to F to A (600 to 0 kWh/m2 per year)*	*Range effects.*
Energy label 6	*Re-scale from G to A (700 to 0 kWh/m2 per year) to F to A+ (600 to -100 kWh/m2 per year).* *Text explanation of A+.*	*Anchoring.* *Range effects.*
Energy label 7	*Text – Total energy consumption.*	*Correcting the size effect bias.*

Another bias that we suspect from the previous qualitative study regards the interpretation of the scale of the energy indicator. If we overlap the scale with the distribution of the Flemish building stock relative to each energy class, the graphs is left skewed, see labels 2.1 and 2.2 in *Figure 17*. We suspect that in the absence of the bar graph, respondents imagine a normal distribution, therefore we will refer to this potential bias as 'normal distribution illusion'. If confirmed, it would mean that people underestimate the percentage of dwellings with a better label than dwelling class C, having an optimistic assessment of the dwellings of the label C and a pessimistic assessment of the Flemish dwelling stock. If confirmed, this bias could be corrected with specifying the median, instead of the mean, since the median value in a left skewed graph is a higher value than the mean, therefore the social norm would mean comparing with a better EPC score.

Methodology

The experimental studies presented in the previous section have the advantage over the field experiments, for example randomized controlled trials (RCTs) for being able to isolate and detect the behavioural mechanism (Lunn and Choisdealbha, 2016). Besides, there are various constraints in releasing different versions of the Flemish EPC for field experiments and detecting the impact on renovation decisions. These are decisions affected by multiple factors over a long period of time and the EPC is not the only source of information. For these reasons we opted for an experimental study. Ten alternative information framings of the energy indicator are tested, that were grouped into seven experimental conditions due to similarities and lack of differences in results, see *Figure 17* and *Table 24*. The study has a between subjects design, each respondent being presented with one experimental condition and the EPC of two dwellings:

- Dwelling class F – red colour, EPC score 580 kWh/m^2 per year
- Dwelling class C – yellow colour, EPC score 230 kWh/m^2 per year

The order in which the two dwellings were presented was randomised. Respondents were students of Architecture and Interior Architecture in different years and the responses were collected in aula before or after the classes during October 2017. In total 224 complete responses were recorded, these being voluntary and not graded for the course. The first (the energy indicator) and the third page of the certificate (the recommendations) for the two dwellings were presented on paper and the questions were filled in online on laptops and smartphones. Respondents were not instructed to look ahead in the papers provided, but they were allowed to the previous pages, including the other dwelling. Therefore, the questions regarding the energy indicator were based only on the first page of the EPC, while the questions regarding recommendations were based on both pages of the certificate. In this paper we present the results regarding the first page of the certificate, the one including the energy indicator, see *Figure 15*.

The main aim of the study is to determine whether information framing plays a role in the comprehension and interpretation of the label. Firstly, we verify whether heuristic thinking interferes with deliberative thinking and whether the hypothesized cognitive biases are confirmed. These biases are 'normal distribution illusion' and 'size effect bias'.

Besides detecting cognitive biases, the aim of the study is to verify if nudges such as social norm, anchoring, range effects and salience are effective. All the experimental conditions are presented in *Figure 17* and *Table 24* summarizes the behavioural insights relative to each label. Besides references such as the mean and the median, the ranges of the scale might work as an anchoring effect in interpreting the EE and energy consumption of a dwelling.

The dependent variables can be classified in two main categories:

- Absolute terms
    - Perceived EE
    - Perceived energy consumption
- Relative terms (compared to the rest of the Flemish stock)
    - Percentage of dwellings with a better label

The first category of questions in the online questionnaire refers to a subjective scale for each individual. Respondents had to rate the dwelling in terms of energy efficiency on a Likert scale from 1 to 5, 1 being 'very inefficient' and 5 'very efficient'. Similarly, they were asked "How much energy do you think an average

Flemish family would consume if they live in this house?" the Likert scale being from 'very few energy' to a 'lot of energy'.

Since the energy consumption is calculated for an average Flemish family, it refers to the energy performance of the dwelling and does not regard the consumption pattern of the users. Thus, the answers regarding the EE and energy consumption should be the same but inverted, the duplication having the purpose to see which concept is understood better and whether there is consistency in the answers.

For the second category of dependent variables, respondents have to assess the dwelling relative to the rest of the building stock – they have to estimate the percentage of Flemish dwellings with a better energy class. If the previous Likert scale is subjective and might be different for each individual, this assessment can be compared with objective figures – 70 per cent for class F and 20 per cent for class C, according to 2014 data (Verbeeck and Ceulemans, 2016). The aim of this question is to verify the hypothesis of a 'normal distribution illusion' and whether respondents are assessing too optimistically a certain class.

Finally, for detecting the 'size effect bias', respondents have to choose which dwelling will have higher energy bills if the same family lives in:

- a dwelling with size of 100 m^2, class F and EPC score of 580 kWh/m^2 per year
- a dwelling with size of 300 m^2, class C and EPC score of 230 kWh/m^2 per year

The energy indicators of the two dwellings were presented, alongside the information of the dwelling size.

Figure 17 Experimental conditions.
Left column (top to down) – Energy label 1.1, 1.2, 1.3, 2.1, 2.2.
Right column (top to down) – Energy label 3, 4, 5, 6, 7.

Main findings

The differences between labels 1.1, 1.2 and 1.3 are very small. For every test we did, no significant difference between them could be found. Therefore, they are presented as the same experimental condition, label 1. Comparably labels 2.1 and 2.1 are presented as the same experimental condition, label 2. This reduces the ten test conditions (*Figure 17*) into 7 energy labels (*Table 24*).

The statistical analysis was computed using RStudio version (2016). For assessing the impact of the experimental conditions on the perceived energy efficiency and energy consumption were performed ANOVA Kruskal-Wallis tests and ordinal logistic regressions. ANOVA Kruskal-Wallis test is suitable for ordinal variables such as the Likert scale values. The ordinal logistic regression model has a parallel regression assumption implying that for all levels of the dependent variable the odds ratios of all the pairs of responses of the independent variable are assumed to be the same.

For the comparison with the rest of the Flemish building stock, firstly we performed a one sample t-test tests to compare the estimation with the actual value for dwelling F (70 per cent) and dwelling C (20 per cent). One sample t-tests treat the discrete variable (the estimation of the percentage of dwellings performing better was measured with a definition of 10 per cent) as a continuous variable. If n large enough ($n \geq 30$) then by the Law of Large Numbers, no assumption concerning the distribution is required. Secondly, we compare the estimation between different experimental conditions with ANOVA Kruskal-Wallis test by ranks.

Perceived energy efficiency

Firstly, we are interested to verify whether various ways of presenting the information (the seven energy labels) have an impact on how respondents interpret and assess the EE of the dwelling. The box plots from *Figure 18* and *Figure 19* illustrate the lower quartile, the median and the upper quartile for the estimated EE of dwelling C and F relative to the experimental conditions. When performing an ANOVA Kruskal-Wallis test by ranks, for a dwelling class C estimated EE differs significantly depending on the way the information is presented (df= 6, chi-squared =17.3, p-value= 0.008), see *Table 25*. For the dwelling in the red spectrum labelled F, no significant differences are found for EE (df= 6, chi-squared = 8.09, p-value= 0.23). Respondents tend to agree that it is a very inefficient dwelling (see *Figure 19*).

Table 25 Dwelling labelled C – Perceived energy efficiency and energy consumption. Results of ANOVA Kruskal-Wallis tests.

	Dwelling C			*Dwelling F*		
	chi-squared	*df*	*p-value*	*chi-squared*	*df*	*p-value*
Estimated energy efficiency	*17.3*	*6*	*0.008***	*8.0876*	*6*	*0.2318*
Estimated energy consumption	*21.1*	*6*	*0.002***	*7.6842*	*6*	*0.2622*
*Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05*						

Subsequently we compared estimated EE of different labels with control condition E1 using the ordinal logistic regression (Proportional-odds cumulative-logit model), see *Table 26 and Table 27.* The advantage of using an ordinal model is that it does not assume that differences between the levels of the response variable are equal, for example, the difference between “very inefficient” and “inefficient” might be different than from “inefficient” and “average”. For the yellow spectrum dwelling class C, respondents assess EE less optimistically seeing labels 5 and 6 compared with control condition label 1. All other comparisons gave no significant differences. Labels 5 and 6 are the rescaled experimental conditions, instead of the scale from class G to A (700 to 0) of the label 1 (control condition), label 5 has a scale ranging from class F to A (600 to 0) and label 6 a scale from class F to A+ (600 to -100), see *Figure 17*. It could be explained by the anchor effect, where the ranges of the scale work as anchors that affect the interpretation of the EPC label and score. Again, for the dwelling class F, no significant differences could be found. The results show that the order in which the dwellings were presented to the respondent influences the estimated EE. The ordinal logistic model controls for order effects by including the order variable besides the experimental conditions.

Table 26 Perceived energy efficiency for dwelling C.
Results of Proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	-6.413	1.040	-6.165	< 0.001***
(Intercept):2	-3.163	0.359	-8.804	< 0.001***
(Intercept):3	-0.575	0.271	-2.127	0.0334 *
(Intercept):4	3.421	0.546	6.262	< 0.001***
QE2	0.482	0.365	1.320	0.187
QE3	0.075	0.497	0.150	0.881
QE4	0.0095	0.490	0.019	0.985
QE5	1.055	0.516	2.044	0.041*
QE6	1.555	0.471	3.297	0.001***
QE7	0.3475	0.467	0.743	0.457
ORDER CF	0.772	0.264	2.922	0.0035**

*Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05*

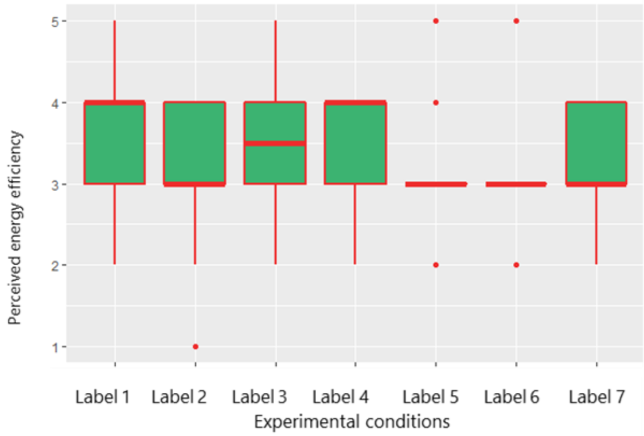


Figure 18 Perceived energy efficiency - Dwelling labelled C
Y axis - 1 very inefficient, 5 very efficient
The box plots illustrate the lower quartile, the median and the upper quartile.

Table 27 Perceived energy efficiency for dwelling F.
Results of proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	0.684	0.299	2.281	0.0226*
(Intercept):2	2.228	0.371	6.006	< 0.001***
(Intercept):3	2.695	0.421	6.405	< 0.001***
(Intercept):4	3.529	0.562	6.279	< 0.001 ***
QE2	0.0103	0.426	0.024	0.981
QE3	0.2165	0.596	0.363	0.716
QE4	-0.272	0.534	-0.509	0.6104
QE5	1.719	1.0328	1.664	0.0961 .
QE6	1.338	0.7804	1.715	0.0864 .
QE7	0.47	0.606	0.776	0.438
ORDER CF	0.74	0.336	2.200	0.0278 *

*Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05*

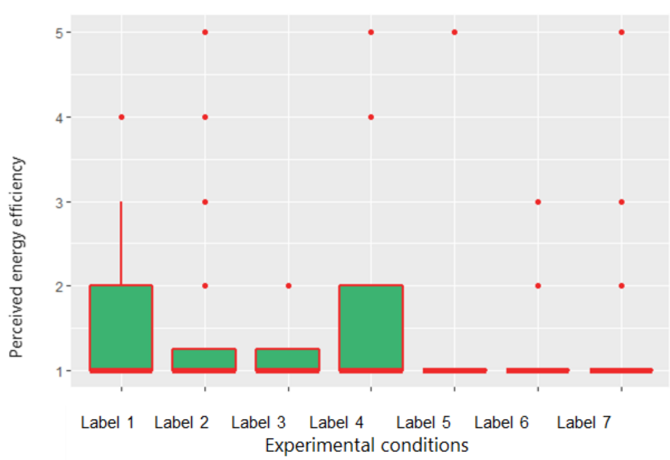


Figure 19 Perceived energy efficiency - Dwelling labelled F.
Y axis - 1 very inefficient, 5 very efficient.
The box plots illustrate the lower quartile, the median and the upper quartile.

Perceived energy consumption

The results of ANOVA Kruskal-Wallis tests show that for a dwelling class C estimated energy consumption differs significantly depending on the way the information is presented (df= 6, chi-squared =21.1, p-value= 0.002), see *Table 25*. For the dwelling in the red spectrum labelled F, no significant differences are found (df= 6, chi-squared = 7.7, p-value= 0.26), respondents tend to agree that it consumes a lot of energy (see *Figure 21*).

The results of the ordinal logistic regression of energy consumption confirm the results of the estimation of EE, with a less optimistic assessment of dwelling C when presented with labels 5 and 6 compared to control condition 1. Additionally, when presented with label 7, they assess only the energy consumption higher than label 1 (see *Table 28*). Labels 5 and 6 are the rescaled experimental conditions, while label 7 contains the information regarding the total energy as plain text, see *Figure 17*.

Another novelty of the results of energy consumption in comparison with EE and the previous ANOVA tests lies in the perceived energy consumption of the dwelling in the red spectrum, labelled F, that is significant for label 6 (see *Table 29*). Also in this case, rescaling as in the experimental condition 6 (from class G to A+) contributes to a less optimistic assessment of the energy consumption of the dwelling.

For both dwellings and for both EE estimation and energy consumption the order in which the dwellings were presented played a significant role. If presented second, the energy consumption of dwelling F is perceived to be higher due to anchoring effect.

Table 28 Perceived energy consumption for dwelling C.

Results of proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	-3.379	0.609	-5.546	< 0.001***
(Intercept):2	0.3402	0.266	1.278	0.201
(Intercept):3	2.952	0.344	8.593	< 0.001***
(Intercept):4	7.243	1.058	6.849	< 0.001***
QE2	-0.523	0.365	-1.433	0.1518
QE3	-0.224	0.492	-0.454	0.649
QE4	-0.328	0.482	-0.680	0.496
QE5	-1.468	0.521	-2.814	0.0049 **
QE6	-1.516	0.469	-3.226	0.0013 **
QE7	-1.681	0.481	-3.498	0.00047 ***
ORDER CF	-1.476	0.278	-5.312	< 0.001***

*Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05*

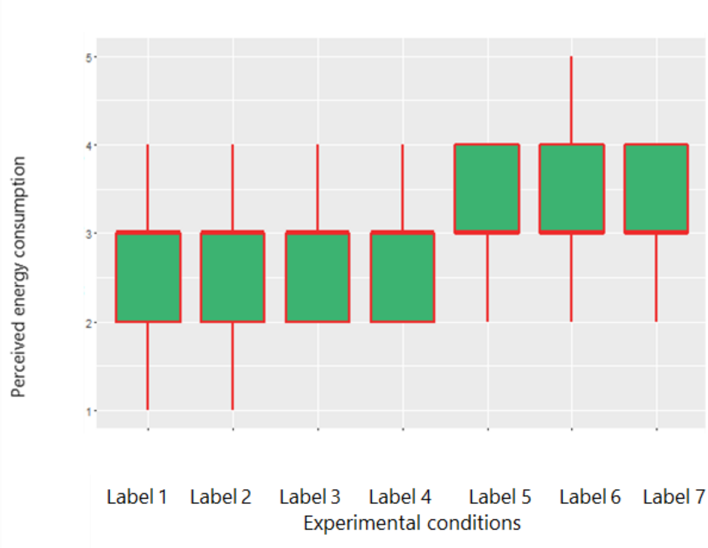


Figure 20 Perceived energy consumption - Dwelling labelled C.
Y axis - 1 few energy, 5 a lot of energy.
The box plots illustrate the lower quartile, the median and the upper quartile.

Table 29 Perceived energy consumption for dwelling F.
Results of proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	-4.836	1.023	-4.728	< 0.001***
(Intercept):2	-2.733	0.416	-6.578	< 0.001***
(Intercept):3	-1.422	0.293	-4.850	< 0.001***
(Intercept):4	0.623	0.268	2.325	0.0201 *
QE2	-0.169	0.362	-0.467	0.640
QE3	-0.551	0.505	-1.091	0.275
QE4	0.1317	0.473	0.278	0.781
QE5	-0.750	0.546	-1.373	0.170
QE6	-1.1687	0.520	-2.250	0.0245*
QE7	-0.310	0.471	-0.659	0.5102
ORDER CF	-0.920	0.270	-3.416	0.00064 ***
Significance	***p-value < 0.001;	**p-value < 0.01;	*p-value < 0.05	

Figure 21 Perceived energy consumption - Dwelling labelled F.
Y axis - 1 few energy, 5 a lot of energy.
The box plots illustrate the lower quartile, the median and the upper quartile.

Comparison with the rest of the Flemish building stock

In the previous subsection we discussed the findings regarding assessing the dwellings in absolute terms, compared to the most and least EE dwelling imagined. Yet, these scales are subjective, therefore another type of comparison is needed. The respondents were asked the percentage of Flemish dwellings with a better label than the dwelling presented. This estimation can be compared with an objective value of the existing building stock, that is 70 per cent for the dwelling labelled F and 20 per cent for the label C, according to data from 2014 (Verbeeck and Ceulemans, 2016).

Firstly, we verify if respondents have estimated correctly this value. *Table 30* summarizes the results of one sample t-test tests, comparing the estimation with the actual value for dwelling F (70 per cent) and dwelling C (20 per cent). For the dwelling F, the mean difference for Labels 1 (control condition), 4, 5, and 7 is significant, therefore the estimation is wrong. With labels 2, 3, and 6 the estimation of the percentage of dwellings performing better was not significantly wrong. Two of the experimental conditions present this information explicitly, either in the form of a bar graph (label 2) or as plain text (label 3). The interesting finding is that by rescaling (label 6), respondents could estimate the percentage of dwellings performing better than the dwelling in the red spectrum (label F) more accurately than with the control condition. Rescaling of label 6 means having the scale from class F to A+ instead of class G to A of label 1. With the control condition, respondents underestimated the percentage of dwellings with a better label than F. This implies an optimistic assessment of the energy performance of the dwelling labelled F or a pessimistic assessment of the rest of the Flemish building stock or both.

As for the dwelling class C, respondents had difficulties to estimate the correct value, independently of the experimental condition, see *Table 30*. For all labels, respondents overestimated the percentage of the dwellings performing better than class C. This implies both a pessimistic assessment of dwellings labelled C and an optimistic assessment of the Flemish buildings in the yellow-green spectrum of the scale.

Secondly, we compare the estimation between different experimental conditions with ANOVA Kruskal-Wallis test by ranks. Only for the estimation of the percentage of dwellings better than class F the differences between experimental conditions are significant.

Table 30 Estimated percentage of dwellings with a better label. Comparison with the data of the building stock.

	Dwelling labelled F Mean[1]	Dwelling labelled C Mean[2]
Label 1	-15.86***	13.43***
Label 2	-3.96	14.17***
Label 3	-6	8**
Label 4	-10.95*	18.09***
Label 5	-12.22*	18.89***
Label 6	-4.58	21.25***
Label 7	-7.39*	15.65***

[1]t.test H0 mean diff (X-70) is equal to 0

[2] t.test H0 mean diff (X-20) is equal to 0

*Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05*

The initial hypothesis was that people imagine a normal distribution on the scale of the percentages relative to the classes, instead of the left skewed distribution, see label 2.1 and 2.2 of *Figure 17*. This would imply that for the dwelling class C respondents would underestimate the estimation of the percentage of the dwellings with a better label. However, the results show this underestimation only for the dwelling labelled F, with the overall mean of the estimation at 60.4 per cent compared to 70 per cent in reality. For the dwelling class C, independently of the experimental condition, the estimated value was substantially higher than the actual figure, 35 per cent compared to 20 per cent in reality. That could imply that individuals imagine a uniform distribution on the scale instead of a normal distribution as hypothesized.

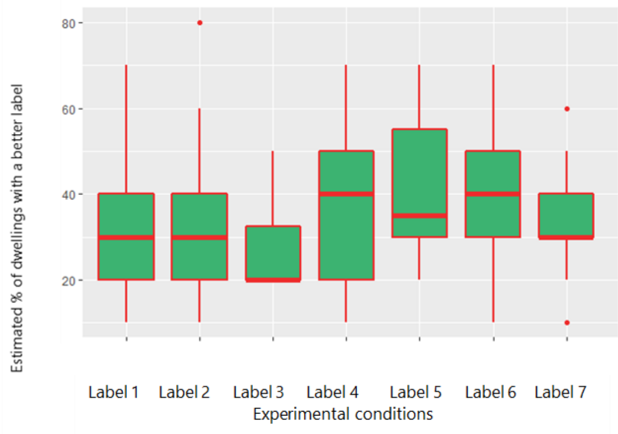


Figure 22 Estimated percentage of dwellings with a better label than the dwelling labelled C. The box plots illustrate the lower quartile, the median and the upper quartile.

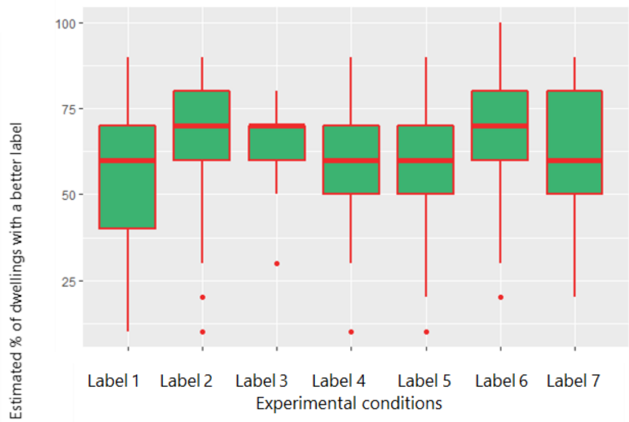


Figure 23 Estimated percentage of dwellings with a better label than the dwelling labelled F. The box plots illustrate the lower quartile, the median and the upper quartile.

Table 31 Estimated percentage of dwellings with a better label. Comparison with the control condition, label 1.

	ANOVA Kruskal-Wallis p-value
Dwelling labelled F	0.0298*
Dwelling labelled C	0.0729
Significance ***p-value < 0.001; **p-value < 0.01 ; *p-value < 0.05	

Size effect bias

At the end of the survey, respondents had to choose which house would mean higher energy bills, given that the same family lives in both – a dwelling with class F (EPC score 580 kWh/m^2 per year) and size 100 m^2 or a dwelling with class C (EPC score 230 kWh/m^2 per year) and size 300 m^2. The purpose of this question was to verify if respondents are aware that the EPC score is relative to the size and that the dwelling C, even though with a better EE, would require more total energy due to the size (69.000 kWh per year versus 58.000 kWh per year). Even though the respondents were students of the Faculty of Architecture, 72 per cent of the answers were wrong. This result confirms the hypothesis of the 'size effect bias'. The label 7 that includes the information about the total energy did not help to overcome this bias. It is important to notice that the label 7 was not presented on the same page with the last question, but it was only present for the previous questions, even though the pages were available for looking back. The 'size effect bias' for dwellings is similar to the 'energy efficiency fallacy' from the study regarding energy label for appliances (Waechter et al., 2015b). In both cases individuals focus only on the energy class, ignoring other information, such as total energy or the size.

Conclusions - Policy implications

In the recent years there is a growing interest to apply the behavioural insights regarding rational and heuristic thinking to various areas of policy making (Dolan et al., 2010, Lourenço et al., 2016, Lunn, 2013). Yet, in the context of promoting EE and energy renovation there are still few behaviourally-informed policies based on evidence. The present study aims to verify in a quantitative way the impact of information framing of the new version of the Flemish EPC on the comprehension and interpretation of the energy indicator. With a correct interpretation of the energy indicator the prospective buyer and renters can make informed purchase and renovation decisions. The goal for 2050 of the Flemish Region is to achieve an EPC energy score of 100 kWh/m^2 per year after renovation for all buildings (Vlaams Energieagentschap). That means that most of the existing dwellings, including the ones having the yellow label C with 230 kWh/m^2 per year label have to be renovated to achieve the goal.

For most of the parameters measured, the alternative design, label 6 showed better results than the control condition label 1. Based on these results, the energy label of the new Flemish EPC was rescaled to classes F to A+ (600 to -100 kWh/m^2 per year) instead of the initial intended G to A (700 to 0 kWh/m^2 per year), see *Figure 16*.

The current laboratory study has the limitation of not differentiating the willingness from the ability to process the information since no incentive was provided to respondents for correct answers. Yet, this lack of incentive is more similar to real-life setting when homeowners are presented with the certificate.

Firstly, results point out towards the bias of 'uniform distribution illusion' that could be corrected with labels 2, 3 and 6. Respondents are imagining the percentage of dwellings relative to each class is a uniform distribution, while in reality it is left skewed. With the control version, individuals assess optimistically the dwelling in the red spectrum (labelled F) and underestimate the percentage of Flemish dwellings with a better label. This wrong perception could influence the purchase and renovation decisions in a negative way. Yet, this wrong perception can be corrected either by explicitly stating the percentage of dwellings performing better either as plain text (label 3) or as a bar graph (label 2), either by rescaling (label 6). The ranges of the scale work as anchors and rescaling contributes to a less optimistic assessment of the energy consumption of the label F and a correct estimation of the percentage of the dwellings with a better label. The efficacy of rescaling and the anchor effect is confirmed by previous studies regarding energy labels for appliances (Waechter et al., 2016a). In the yellow spectrum, on the other hand, individuals assess pessimistically the dwelling with label C and overestimate the percentage of dwellings doing better. None of the experimental conditions corrected this bias, but its effect on the purchase and renovation decisions theoretically is not negative as for the red spectrum.

Secondly, the interpretation of the control condition label 1 was prone to biased interpretation – 'size effect bias'. The vast majority of the respondents (72 per cent) are not aware that the EPC score is relative to the size. Yet, stating in text the total energy did not prove to be effective and other ways of communicating this message should be found. This bias is similar to the 'energy efficiency fallacy' detected for the label of appliances, where consumers focus only on the energy class, ignoring other information, such as the total energy, the size or the power (Waechter et al., 2015b). The total energy consumption is specified on the label for appliances, yet in the case of the Flemish EPC neither the value of the total energy nor the size of the dwelling is presented on the first page of the certificate next to the energy indicator.

Often the application of behavioural insights is associated exclusively to nudging. Even if nudging is not the purpose, various policies including mandates such as the EPC should be tested before upscaling. No information is neutral and this study confirms it, since without a prior testing, the scale of the energy indicator might have contributed to an optimistic interpretation of the energy performance of the dwellings in the red spectrum. These are the dwellings that should be the target of renovation policies, not only for high consumption but also for health hazards.

In the recent years there is a growing application of behavioural insights to policy making, many governmental agencies collaborating with researchers or even setting up their own behavioural units (Halpern and Sanders, 2016). Certain changes to the policy instruments, for example the EPC in the UK were based merely on assumptions of behavioural insights that could be applicable (BIT, 2011a). Nevertheless, evidence sometimes shows contradictory results, depending on the context or some hypothetical nudges can even backfire. In the framework regarding communicating energy metrics elaborated by Yoely et al., longer time frames are suggested for energy savings (Yoeli et al., 2017), while in the changes for the British EPC, substitution of five years to three years is suggested for presenting energy savings due to discounting the future (BIT, 2011b). The impact of certain policy instruments such as the EPC are prolonged over time, the previous version of the Flemish EPC was in use for almost 10 years and the certificates released are valid for another 10 years, therefore its comprehension and interpretation is worth testing before the release.

In many policy areas including energy efficiency, the laboratory experimental research is underused compared to field experiments, such as RCTs (Lunn and Choisdealbha, 2016). There are many contexts where RCTs are not applicable. Renovation decisions are difficult to track over time, since many recommended measures do not need a building permit. Moreover, the cause of such difficult decisions cannot be separated from complex reality and the EPC is only one of the many sources of information in play. The same is valid for home purchase decisions. Therefore, lab experiments and similar techniques can inform policy makers with applicable insights before the policy instrument is launched and scaled up. The advantage of lab experiments over field experiments is the possibility to isolate, detect and validate the behavioural mechanism behind the success of a control condition. The quantitative experimental studies have to be based on previous qualitative analysis, such as focus groups, that allows exploring the implications of theoretical behavioural insights to this particular context. The present research, is an example of how researchers can collaborate with policy makers for elaborating evidence-based policies.

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Chapter 5

Range effects or social norm? The importance of information framing for the energy labels[6]

Abstract

Current policies promoting energy efficiency in the residential sector rely on the assumption that homeowners are able to comprehend and correctly interpret technical information, like on the European Union's energy performance certificate (EPC) for dwellings. The study challenges this assumption and takes into account bounded rationality and the system 1 interpretation of information. In collaboration with the Flemish Energy Agency, responsible for the implementation of a new EPC version, different information framings (wording, layout and design) of the energy label and the recommendation pages were tested in laboratory experiments with homeowners. Rescaling of the energy label from G-A to F-A+ corrected an overly favourable assessment of dwellings labelled F and C and led participants to perceive a greater need for renovation. The addition of a graph that implements a social norm manipulation backfires. The study is an example of pre-testing behaviourally-informed policy.

[6] The present chapter is based on the article "*Range effects or social norm? Importance of the information framing for the energy labels*" by Taranu Victoria, Lunn Pete & Verbeeck Griet to be submitted to the Journal Behavioral Science & Policy.

Introduction

In view of the European Union (EU) policy target of a decarbonised building stock for 2050, promoting energy renovation in the residential sector is a priority (EC, 2016). One of the mandatory policies in EU member states is the energy performance certificate (EPC) scheme. In the residential sector, the energy label is required at the point of sale or rental of the property (EC, 2002, EC, 2010). The goal is to enable prospective buyers and renters to take into account the energy performance of the dwelling in their purchase and rental decision. Another aspect of the certificate, the recommendations, aims to encourage the uptake of energy-efficient renovation measures.

In order to have an impact on the market, the certificate needs to be comprehended and correctly interpreted by consumers. Yet, the translation of technical terms and concepts has proven to be more difficult than expected in the case of energy labels for appliances (Waechter et al., 2016a, Waechter et al., 2015a, Waechter et al., 2015b) and vehicles (Larrick and Soll, 2008). In the context of energy labels for dwellings, most studies have focused on the calculation method and quality assurance of the certifiers (BPIE, 2010, Arcipowska et al., 2014, Harsman et al., 2016, Maivel et al., 2016) or the impact on the market (Mudgal et al., 2013, Christensen et al., 2014, Wahlstrom, 2016). Few studies take into account how information on the certificate is framed (content, wording and layout) (BPIE, 2018, IDEAL EPBD Project, Backhaus et al., 2011) and these reports point out the need for further research. No studies explicitly take into account system 1 thinking and test certificates experimentally. The UK certificate was modified based on Behavioural Insights Team recommendations by decreasing the timespan of the energy savings from five to three years. This modification was based on the hypothesis of present bias (BIT, 2011b), but its impact was not tested.

In Flanders (a region that represents 59 per cent of residential buildings in Belgium (ADSEI, 2018)) the EPC scheme for residential buildings was first introduced in 2009 (Mudgal et al., 2013). Unlike in the majority of EU countries, the certificate in Flanders originally contained an EPC score (a number) instead of an energy label (a letter). In the EPC version in use the energy performance indicator is presented as an EPC score on a continuous scale, see *Figure 24a*, while the recommendations are presented as plain text, see *Figure 25a*. In a new version of the certificate to be released in January 2019 (Vlaamse overheid, 2018), the energy class (e.g. F) is presented as well as the EPC score (e.g. 580 kWh/m^2 per year), as shown in *Figure 24b*, while the recommendations are presented in a table instead of plain text (*Figure 25b*).

The current study was undertaken in collaboration with the Flemish Energy Agency, that is responsible for the implementation of the EPC scheme in Flanders. The study pre-tested alternative information framings of the energy label and the recommendations via a laboratory experiment with homeowners. The hypotheses were based on a combination of previous literature the results of a previous focus group with experts and pilot experiments. The findings of the focus groups and pilots indicated that interpretation of the certificate could be biased, towards overestimation of the energy efficiency of the dwellings, in particular at the red end of the spectrum. In the experiment described here, we tested whether nudges such as range effects and a social norm manipulation correct this bias. In addition, we investigated whether homeowners realise that the EPC score is calculated per unit area and is therefore informative about energy usage only relative to the size of the dwelling. It is a theoretical value calculated based on the characteristics of the dwelling and does not account for consumption patterns of the user. Besides comprehension and interpretation, our outcome variables included willingness to renovate.

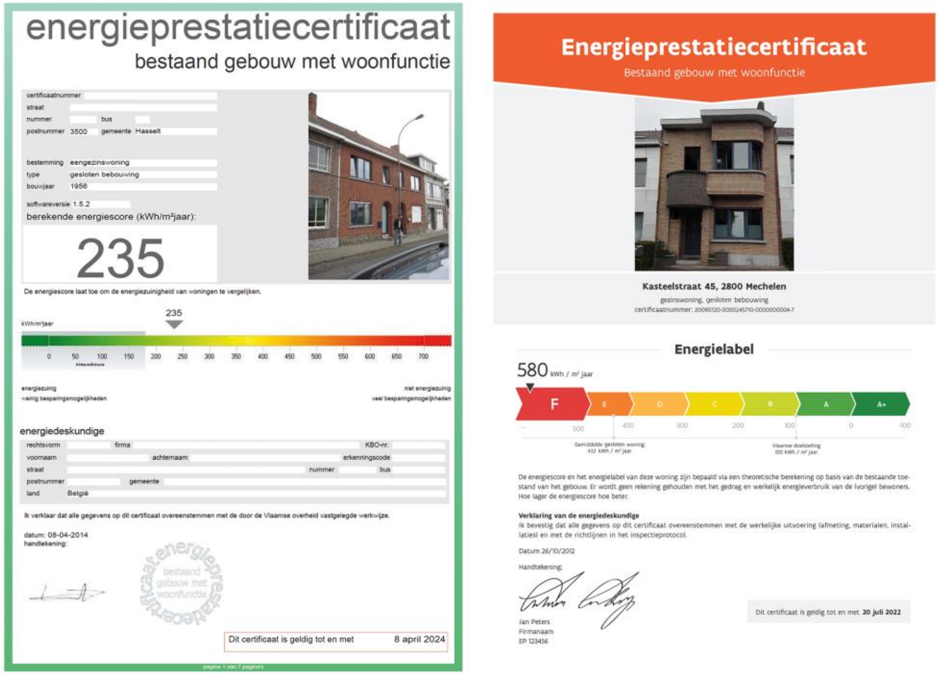

Figure 24 The energy label page. From left to right - 24a The certificate currently in use in Flanders; 24b The new version of the Flemish certificate under trial.

energieprestatiecertificaat

bestaand gebouw met woonfunctie

certificaatnummer
straat nummer bus
postnummer gemeente Hasselt

Aanbevelingen voor de verbetering van de isolatie van het hellende dak

Aanbeveling: plaats (extra) isolatie in het hellende dak

58,5 m^2 hellend dak is onvoldoende geïsoleerd.

Door het hellende dak (bijkomend) te isoleren, zal het energieverbruik verminderen. Een energiezuinig dak heeft een U-waarde die kleiner is dan 0,4 W/m^2K.

Aanbevelingen voor de verbetering van de isolatie van het platte dak

Aanbeveling: als het platte dak niet of onvoldoende geïsoleerd is, plaats dan (bijkomende) isolatie

Van 31,3 m^2 plat dak is de aanwezigheid van isolatie onbekend.

Verder (destructief) onderzoek naar de onbekende invoergegevens is aan te raden. Als het platte dak niet of onvoldoende geïsoleerd is, zal het energieverbruik verminderen door het platte dak (bijkomend) te isoleren. Een energiezuinig dak heeft een U-waarde die kleiner is dan 0,4 W/m^2K.

Aanbevelingen voor de verbetering van de beglazing of transparante delen

Aanbeveling: plaats hoogrendementsbeglazing

De woning bevat 12,6 m^2 dubbele beglazing. Het energieverbruik zal verminderen door gewone dubbele beglazing te vervangen door hoogrendementsbeglazing.

Energiezuinige beglazing heeft een U-waarde die kleiner is dan 1,6 W/m^2K.

Aanbevelingen voor de verbetering van de isolatie van de buitenmuren

Aanbeveling: plaats (extra) isolatie in de buitenmuren bij de uitvoering van een grondige renovatie

39,9 m^2 buitenmuur is niet geïsoleerd.

Door de buitenmuren bij de uitvoering van een grondige renovatie (bijkomend) te isoleren, zal het energieverbruik verminderen. Voorafgaand onderzoek naar de isolatiemogelijkheden is aan te raden. Een energiezuinige buitenmuur heeft een U-waarde die kleiner is dan 0,6 W/m^2K.

Aanbeveling: als de buitenmuren niet of onvoldoende geïsoleerd zijn, onderzoek de mogelijkheid om de buitenmuren bij de uitvoering van een grondige renovatie (bijkomend) te isoleren

Van 14,5 m^2 buitenmuur is de aanwezigheid van isolatie onbekend.

Verder (destructief) onderzoek naar de onbekende invoergegevens en eventuele isolatiemogelijkheden is aan te raden. Als de buitenmuren niet of onvoldoende geïsoleerd zijn, zal het energieverbruik verminderen door de buitenmuren (bijkomend) te isoleren. Een energiezuinige buitenmuur heeft een U-waarde die kleiner is dan 0,6 W/m^2K.

Aanbevelingen voor de verbetering van de isolatie van de vloer die grenst aan een kelder of aangrenzende onverwarmde ruimte

Aanbeveling: plaats (extra) isolatie in de vloer

8,0 m^2 vloer is niet geïsoleerd.

Door de vloer die grenst aan een kelder of aangrenzende onverwarmde ruimte (bijkomend) te isoleren, zal het energieverbruik verminderen. Een energiezuinige vloer heeft een U-waarde die kleiner is dan 0,4 W/m^2K.

Aanbevelingen voor de verbetering van de isolatie van de vloer op volle grond

Aanbeveling: plaats (extra) isolatie in de vloer bij de uitvoering van een grondige renovatie

38,4 m^2 vloer is niet geïsoleerd.

Door de vloer op volle grond bij de uitvoering van een grondige renovatie (bijkomend) te isoleren, zal het energieverbruik verminderen. Voorafgaand onderzoek naar de isolatiemogelijkheden is aan te raden. Een energiezuinige vloer heeft een U-waarde die kleiner is dan 0,4 W/m^2K.

Aanbeveling: als de vloer niet of onvoldoende geïsoleerd is, onderzoek de mogelijkheid om de vloer bij de uitvoering van een grondige renovatie (bijkomend) te isoleren

Van 32,9 m^2 vloer is de aanwezigheid van isolatie onbekend.

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Energieprestatiecertificaat Kasteelstraat 45, 2800 Mechelen | 20090720-0000245710-0000000004-7 3 / 19

Overzicht aanbevelingen

In deze tabel vind je aanbevelingen om jouw woning energiezuiniger te maken. Deze aanbevelingen zijn gebaseerd op piste 1. Kan je ze niet allemaal uitvoeren, dan helpen ze je ook om via piste 2 de doelstelling te halen. Consulteer een specialist voordat je aan de renovatiewerken start. De volgorde in deze tabel is automatisch bepaald en is niet noodzakelijk de juiste volgorde om aan de slag te gaan. Dit is enkel een eerste indicatie puur gericht op energieprestatie.

HUIDIGE SITUATIE	AANBEVELING	INDICATIE GEMIDDELDE PRIJS *
Daken 121 m^2 dak is (vermoedelijk) niet geïsoleerd.	Plaats isolatie.	€ 12.000- 16.000
Vensters 17 m^2 venster heeft enkele beglazing en weinig performante profielen.	Vervang schrijnwerk.	€ 8 000- 9 000
Verwarming Een deel van de woning wordt inefficiënt verwarmd.	Plaats een efficiënt verwarmingssysteem.	€ 4500- 6500
Vensters 10 m^2 dubbele beglazing is weinig energiezuinig.	Vervang glas.	€ 6 000- 8 000
Gevels 140 m^2 gevel is niet geïsoleerd.	Plaats isolatie.	€ 13500- 15 000
Zonne-energie Er zijn geen zonnepanelen aanwezig.	Overweeg de plaatsing van zonnepanelen.	€ 7500-10 000
Gevels 78 m^2 gevel is energiezuinig maar voldoet nog niet aan de doelstelling.	Plaats eventueel (bijkomende) isolatie.	
Vloeren 19 m^2 vloer is energiezuinig maar voldoet nog niet aan de doelsteling.	Plaats eventueel (bijkomende) isolatie.	

Energetisch helemaal niet in orde · Energetisch niet in orde · Zonne-energie · Energetisch redelijk ok, maar net niet voldoende voor doelstelling

* De prijzen worden automatisch berekend en geven een indicatie van de gemiddelde marktprijs voor dit type werken. Dit is niet noodzakelijk de prijs die u betaalt voor uw renovatie. Meer info over de prijsberekening in de bijlage van dit certificaat.

Figure 25 The recommendations page. From left to right – 25a The certificate currently in use in Flanders; 25b The new version of the Flemish certificate under trial.

Previous experimental studies regarding energy labels

The EPC and information campaigns promoting energy renovation include a lot of technical information about the current energy performance of the dwelling and recommendations for energy efficiency upgrades. The assumption is that homeowners are able and willing to engage in deliberative thinking. Yet, previous studies in similar contexts, such as those involving energy labels for appliances, vehicles and heating systems, provide evidence of bounded rationality and biased interpretation of efficiency metrics (Larrick et al., 2015, Larrick and Soll, 2008, Waechter et al., 2016a, Waechter et al., 2015a, Waechter et al., 2015b, Waechter et al., 2016b, Newell and Siikamaki, 2014, Newell and Siikamaki, 2015). All the energy labels, including the EPC, use technical terms and concepts that have to be "translated" for homeowners. Information framing can affect this process of translation, with impacts on comprehension, interpretation and decision making. One well-known example (Larrick and Soll, 2008) shows that the choice of units miles per gallon (MPG) can undermine understanding of the energy efficiency of vehicles. MPG is a non-linear indicator of fuel efficiency but is perceived as linear, leading people to undervalue improvements and, consequently, the replacement of fuel-inefficient cars. A policy recommendation was to use gallons per 10,000 miles instead of MPG.

One danger associated with classification is what has been termed the 'energy efficiency fallacy' (Waechter et al., 2015b). Classifications are awarded relative to other products of the same type, thus, a high classification (e.g. A) may lead consumers to believe that they are purchasing something that has low energy usage, without taking into account the fact that the particular product type (a freezer, a big television) implies high energy use. Support for the existence of this fallacy comes from a series of laboratory experiments on the energy labels of appliances, in which the energy efficiency class (e.g. A) and total annual electricity consumption (e.g. 100 kWh/year) were independently manipulated. When assessing products for energy-friendliness, participants' estimates were based only on the energy efficiency class, largely ignoring the information on the annual consumption. This 'energy efficiency fallacy' might be caused by the salience of the energy efficiency class and it might denote a heuristic interpretation of the certificate. The findings were confirmed by experiments with eye-tracking technologies by the same authors (Waechter et al., 2015a) (Waechter et al., 2016b). The salience effect of the energy class for appliances was also confirmed by another study (Blasch et al., 2016) where consumers used a heuristic strategy to solve the optimization problem according to a salient characteristic (price or energy class). The present study explicitly tested whether homeowners understand that the EPC score does not translate directly into energy usage for heating because it scales with the size of the house, or whether they display the equivalent of the 'energy efficiency fallacy' – the size effect.

Other work has focussed on the range of classifications presented on the scale. For appliances, ranges of the scale play a role in the perceived difference in energy efficiency between appliances from different classes (Waechter et al., 2016a). Due to the plus sign, the perceived difference between classes of A+++ to D scale is lower compared to A to G scale. The results suggest potential benefits from rescaling the existing energy label or eliminating the plus sign, similarly to the recommendations presented in (EC, 2014).

Besides experiments with energy labels for appliances, similar studies have been undertaken for the US Energy Guide label for water heaters (Newell and Siikamaki, 2015, Newell and Siikamaki, 2014). Various information framings have been tested such as monetary savings, physical energy use and carbon dioxide emissions in order to determine individual discount rates. Results show that information on the monetary value of energy savings was the most important guiding element for choosing cost-effective investments (Newell and Siikamaki, 2014). On the other hand, other studies point out that communicating environmental impact could be more effective than communicating monetary savings in order to trigger pro-environmental behaviour (Schwartz et al., 2015), since using monetary incentives might undermine the intrinsic motivation.

In the implementation of the EPC scheme for residential buildings, few guidelines were provided by the EU directives (EC, 2002, EC, 2010) and member states had some freedom to choose both the calculation method and the way the information was presented (framed). In this paper, we focus on the latter. By framing we mean the wording, the layout and the design of the presented information.

Framing of the EPC across EU member states

Even though all European certificates have the same two key messages – the current energy performance of the dwelling (energy label) and the potential to improve it (recommendations), the framing of the information varies considerably. Our previous study compared nine European EPCs from the point of view of framing and whether they made use of behavioural insights (Taranu and Verbeeck, 2017). The comparative analysis revealed two main strategies for the EPC scheme, such that it either offered only a first insight into the energy performance of the dwelling, employing one or two pages with simple messages, or it provided detailed energy advice (7–14 pages of technical information). The study also revealed a wide range of available information framings for the energy label and the recommendations, including the metrics. Many countries did deploy nudges, either in an implicit or explicit way, aiming to make use of social norms, anchoring, or ways to lessen discounting of the future.

The findings of the comparative analysis were used to inform a focus group study with experts in Flanders. The aim was to narrow down the possible information frames to a set that could be tested in a laboratory experiment. A pilot test of the laboratory experiment was then carried out with students from the Faculty of Architecture, to further narrow down frames for testing. The findings of this pilot study are summarised in the paper (Taranu et al., forthcoming 2018) and form the basis for the hypotheses of the laboratory study with homeowners, which we present in the following section.

Experimental study on the energy label for dwellings

Flemish homeowners were recruited among the administrative staff of a university and among participants of information sessions organized by local NGOs. Participation was incentivised via a lottery prize – a voucher of 100 euros for IKEA. 123 useable responses were recorded. The experimental sample was representative by age and gender but somewhat more highly educated than the general population of homeowners in Flanders.

Each respondent was presented with the energy label and recommendation page of certificates for two dwellings:

- red label F and the EPC score of 580 kWh/m^2 per year, see *Figure 24b*;
- yellow label C and the EPC score of 230 kWh/m^2 per year.

Even though label C of 230 kWh/m^2 per year is in yellow, it is still an inefficient dwelling, as it is far from the policy goal for existing dwellings of 100 kWh/m^2 per year set for 2050 for the Flemish region with the Renovation Pact (Vlaams Energieagentschap, 2018).

The experiment had a between-subjects design - the certificates of both dwellings presented to one respondent had the same design (same experimental condition). The experiment had three aspects – the energy label (E), the recommendations (R) and a dwelling size (S) explanation. First the energy label page of the first dwelling was presented on paper. Participants then answered questions about it on the computer. Then the recommendations page (R) was presented on paper, followed by its questions, again on the computer. The process was then repeated for the second dwelling. Respondents could look back to the previous pages of the certificates but could not modify their online answers. The last question probed understanding of the relationship between the rating and the size of the house. At this stage, the energy label pages of both dwellings were presented again, with different experimental conditions varying the explanation of how the rating related to the size of the dwelling (S). The order in which the dwellings were presented and the combinations between E, R and S were randomised.

Experimental design - Part 1 Energy label

For this part of the study a 2x2 between-subjects design was used, with factors "rescale" (range effect) and "graph" (a social norm manipulation). By rescale we mean that the number of energy classes remained the same, seven, but the range of the scale shifted between conditions from the initial G to A (700 to 0 kWh/m^2 per year) to F to A+ (600 to -100 kWh/m^2 per year), see *Figure 26a* and *Figure 26b*.

The second factor was the presence or absence of a graph that presented the relative percentage of certified dwellings of each energy class, according to EPC database of 2014 (Verbeeck and Ceulemans, 2016), as shown in *Figure 26c* and *Figure 26d*. The aim of this manipulation was to provide a salient visual cue as to the performance of the dwelling relative to others, i.e. a social norm manipulation.

Thus, the following four experimental conditions of the energy label (E) resulted, see *Figure 26*:

- E1 control condition no rescale (classes from G to A) and no graph, see *Figure 26a*.
- E2 rescale (classes from F to A+) and no graph, see *Figure 26b*.
- E3 no rescale (classes from G to A) and graph, see *Figure 26c*.
- E4 rescale (classes from F to A+) and graph, see *Figure 26d*.

After respondents were presented with the energy label page, the questions generated the following response variables:

- Perceived energy efficiency of the dwelling (Likert scale 1 to 7 from 'very inefficient' to 'very efficient').
- Perceived energy consumption for an average Flemish family living in the dwelling (Likert scale 1 to 7 from 'very low' to 'very high').
- Estimation of the percentage of dwellings with a better label (sliding bar from 0 to 100 per cent).
- Perceived required renovation of the dwelling (Likert scale 1 to 7 from 'no renovation' to 'deep renovation')
- Willingness to renovate if the respondent were the owner (Binary answer Yes/No with field for comments)

Based on the results of the focus group with the experts and the pilot test with students the following hypotheses were formulated:

- Rescaled version (E2 and E4) and the graph (E3 and E4) will contribute to a lower perceived energy efficiency and a higher

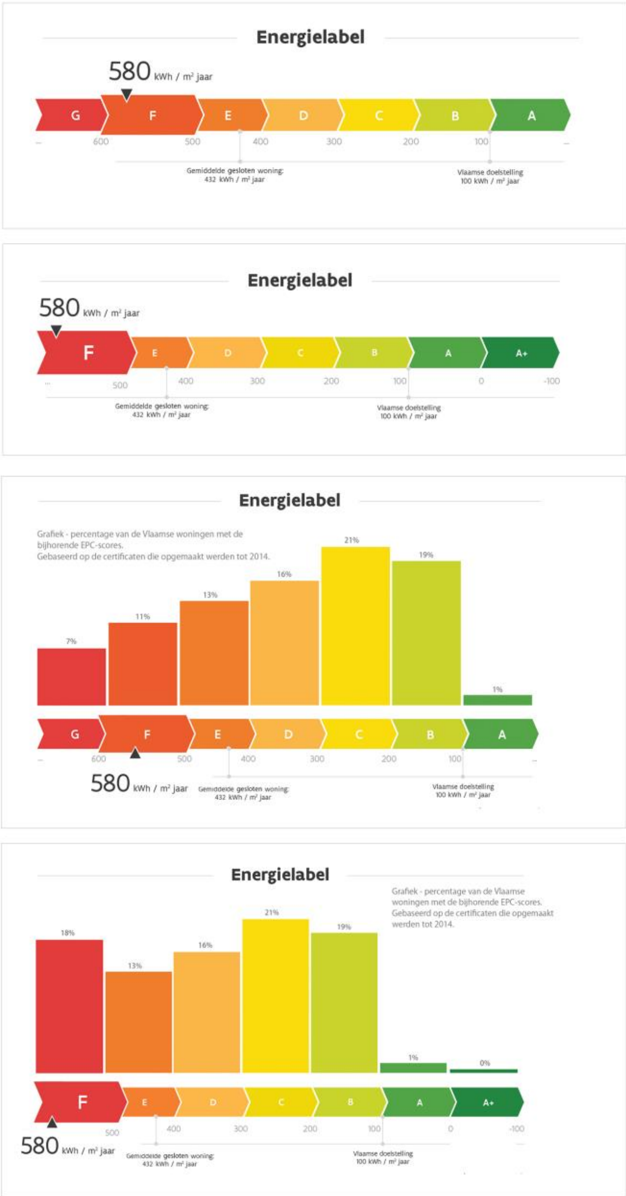


Figure 26 Experimental conditions of the energy label (E). From top down – 26a experimental condition E1 (control condition); 26b experimental condition E2 (rescale); 26c experimental condition E3 (graph); 26d experimental condition E4 (graph and rescale).

- energy consumption of dwellings labelled F and C compared to the control condition (E1).
- In the control condition (E1), respondents will assess the energy performance of the dwelling labelled F (red spectrum of the scale) too favourably in comparison with the rest of the dwelling stock.
- The wrong estimation of dwellings labelled F in comparison with the rest of the dwelling stock will be corrected by rescaling or adding the graph (E2, E3, E4).
- Rescaled version (E2 and E4) and the graph (E3 and E4) will contribute to a higher perceived need for renovation and will improve the willingness to renovate compared to respondents presented with the control condition (E1).

Experimental design - Part 2 Recommendations

After the energy label, the page with recommendations for improving the energy performance was presented. Each respondent experienced one of the following experimental conditions, see *Figure 28*:

- R1 control condition with the estimated price of the measures in the last column on the right, see *Figure 28a*.
- R2 with the estimated price of the measures (second last column) and the energy class achieved after the uptake of a group of recommendations (last column), see *Figure 28b*.
- R3 with the estimated price of the measures (second last column) and monetary savings expressed in percentage (last column), see *Figure 28c*.
- R4 with the estimated price of the measures (second last column) and CO_2 savings expressed in percentage (last column), see *Figure 28d*.

Based on the literature review, the following hypotheses were formulated:

- Showing the benefits of the recommended measures in terms of new energy class achieved (R2), monetary savings (R3) or CO_2 savings (R4) will improve perceived need for renovation and willingness to renovate compared to control condition (R1).

- Framing information as CO_2 savings (R4) will improve perceived need for renovation and willingness to renovate compared to the control condition and monetary savings (R3).

Although the results of the pilot test with the students showed no impact of the different information framing of the recommendations on willingness to renovate (Taranu et al., forthcoming 2018), the student sample may have been inappropriate for renovation decisions. Based instead on previous literature we expected different results in a sample of homeowners.

Experimental design- Part 3 Size effect

After completing the tasks in relation to the energy label and recommendations for both dwellings, a final question followed. The aim was to verify whether respondents were aware that the EPC score of the energy class is relative to the size of the dwelling, being expressed in kWh/m^2 per year. Respondents were presented again with the energy labels of the two dwellings, and they had to decide which one would result in the higher energy bill, assuming that the same family occupied the house:

- Dwelling 3

EPC score of 580 kWh/m^2 per year

Size 100m^2

Terraced house

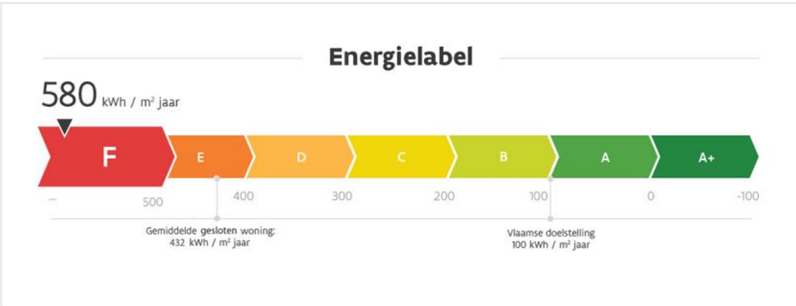
- Dwelling 4

EPC score of 230 kWh/m² per year

Size 300m²

Terraced house

In this case the two experimental conditions were without (S1) or with (S2) the explanation and the total energy, see *Figure 27a* and *Figure 27b*. Lastly, at the end of the study, participants responded to some questions about their socio-demographic background.



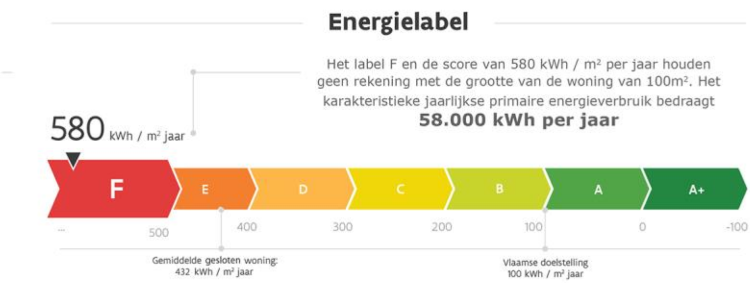


Figure 27 Experimental conditions of the size effect (S) From trop down – 27a experimental condition S1 (control condition); 27b experimental condition S2 (total energy explanation);

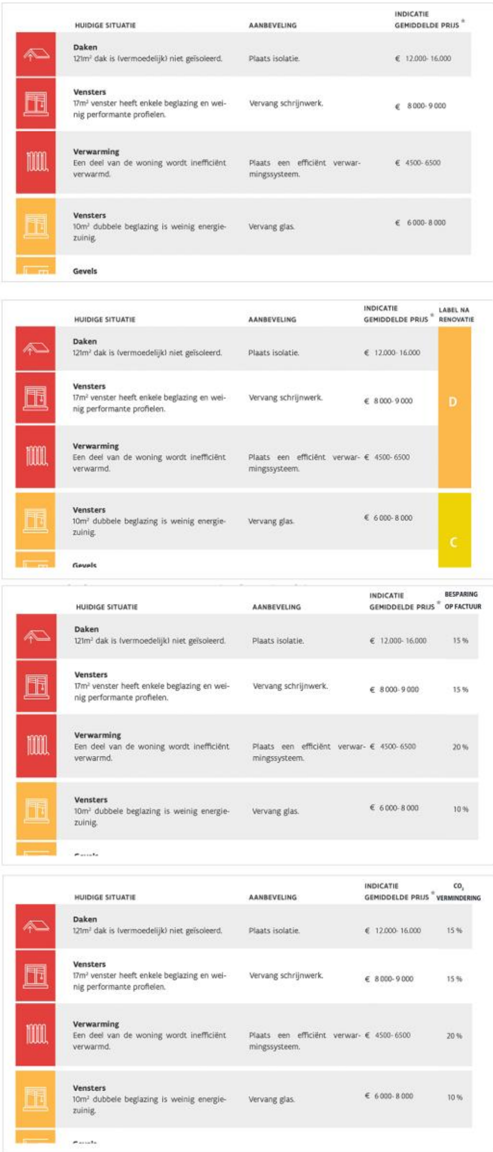


Figure 28 Experimental conditions of the recommendations (R) From trop down – 28a experimental condition R1 (control condition); 28b experimental condition R2 (label achieved); 28c experimental condition R3 (savings monetary); 28d experimental condition R4 (savings CO_2).

Results of the study

For assessing the impact of the experimental conditions on the perceived energy efficiency, energy consumption and need for renovation we performed the following statistical tests – ANOVA Kruskal-Wallis tests, that are suitable for ordinal variables such as the Likert scale values. Subsequently, we have performed ordinal logistic regression analysis (Proportional-odds cumulative-logit model). The ordinal logistic regression model has a parallel regression assumption implying that for all levels of the dependent variable the odds ratios of all the pairs of responses of the independent variable are assumed to be the same. In the following subsections the significant results of the proportional-odds cumulative-logit model are summarised, while the complete results are presented in Attachments. For the willingness to renovate and the impact of the experimental conditions S on the comprehension of the size effect were performed Pearson's Chi-squared tests. The statistical analysis was computed using RStudio version (2016).

For the comparison with the rest of the Flemish building stock, firstly we performed a one sample t-test to compare the estimation with the actual value for dwelling F (70 per cent) and dwelling C (20 per cent). One sample t-tests treat the discrete variable (the estimation of the percentage of dwellings performing better was measured with a definition of 10 per cent) as a continuous variable. If n large enough ($n \geq 30$) then by the Law of Large Numbers, no assumption concerning the distribution is required. Secondly, we compared the estimation between different experimental conditions with ANOVA Kruskal-Wallis test by ranks.

Part 1 Energy label

Energy label vs. perceived energy efficiency

Dwelling F

Firstly, the impact of the four designs of the energy label on the perceived energy efficiency was investigated. ANOVA Kruskal-Wallis tests were performed, followed by ordinal logistic regression analysis (Proportional-odds cumulative-logit model). For label F, with experimental condition E2 (rescaled) the energy efficiency of the dwelling was assessed to be lower than with the control condition E1, see *Table 33* and *Figure 29a*. This difference relates to rescaling of the range from the initial G-A to F-A+, see *Figure 26a* and *Figure 26b*. Therefore with the scale ranging from F to A+ (600 to -100 kWh/m² per year) the same label F having the same EPC score of 580 kWh/m² per year is perceived less favourably than with the initial scale G to A (700 to 0 kWh/m² per year).

The addition of the graph had the opposite effect. With E4 the energy efficiency of dwelling labelled F was perceived to be higher than with E2, both experimental conditions being rescaled but E4 having also the graph. This difference was marginally statistically significant (see *Table 33*). As we can see from *Figure 29*, the addition of the graph on top of rescaled label (E4) presents more variability that means less consensus in estimating the energy efficiency of the dwelling. Respondents presented with the graph chose less extreme values on the response scale, in this case being the "very inefficient" assessment of dwelling F.

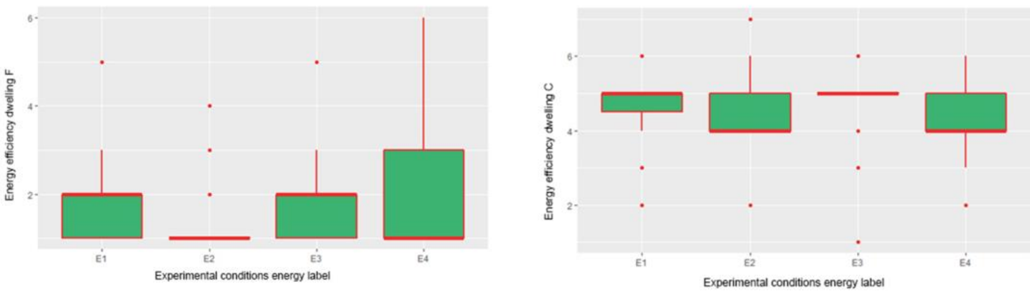


Figure 29 Energy label vs. perceived energy efficiency.
From left to right - 29a Dwelling labelled F; 29b Dwelling labelled C.
The box plots illustrate the lower quartile, the median and the upper quartile.

Table 32 Energy label vs. perceived energy efficiency and energy consumption

		ANOVA Kruskal-Wallis		
		chi-squared	df	p-value
Estimated energy efficiency	Dwelling F	12.5	3	0.006**
	Dwelling C	13.5	3	0.004**
Estimated energy consumption	Dwelling F	9.57	3	0.02*
Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05				

Dwelling C

For dwelling labelled C the effect of rescaling was confirmed with ordinal logistic regression, see *Table 33*.

Table 33 Energy label vs. perceived energy efficiency and energy consumption.

		Ordinal logistic regression[1] relative to control version Label 1		
		Energy labels/ effect	Estimate	P-value
Estimated energy efficiency	Dwelling F	Label E2	1.45	0.007**
		rescale	1.45	0.007 **
	Dwelling C	Label E2	1.36	0.008 **
		Label E4	1.46	0.004 **
		rescale	1.36	0.008 **
		Order effect CF-FC	1.07	0.003 **
Estimated energy consumption	Dwelling C	Label E4	-1.12	0.018 *

[1]The complete results of Proportional-odds cumulative-logit model are presented in Attachments.

Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05

With E2 and E4 the energy efficiency of the dwelling was perceived to be lower than with control condition E1. Even though label C of 230 kWh/m^2 per year is in yellow, it is still an inefficient dwelling, therefore dwellings labelled C are also a target for renovation policies. In addition to the above results, we also recorded an order effect. When presented after dwelling F, the energy efficiency of dwelling C was perceived more favourably (ordinal logistic regression, p-value= 0.003, see *Table 33*).

Energy label vs perceived energy consumption

After energy efficiency, respondents had to assess the total energy consumption of the dwelling with a Likert scale from 1 (very low) to 7 (very high), assuming that an average Flemish family lives in it. In order to estimate the total energy consumption respondents also needed to know the size of the dwelling, since the energy label and the EPC score are relative to the size. Yet, in all the experimental conditions E1 to E4 this information was not presented, similarly to the preliminary and final versions of the Flemish EPC (Vlaamse overheid, 2018). For this question we assumed that the same size was implied for both dwellings and so that this response would be the inverse of the energy efficiency. The purpose of the question was to see which of the concepts was more clear for respondents.

Dwelling F

The results of ANOVA Kruskal-Wallis tests show a difference in assessing energy performance of dwelling F, see *Table 32*. However, ordinal logistic regression revealed that the effects of scale, graph and their joint effect were not significant.

Dwelling C

For dwelling C, respondents presented with E4 (rescale + graph) assessed the energy consumption to be higher than those in control condition E1, see *Table 33*, though again ordinal logistic regression of the joint effect was not significant.

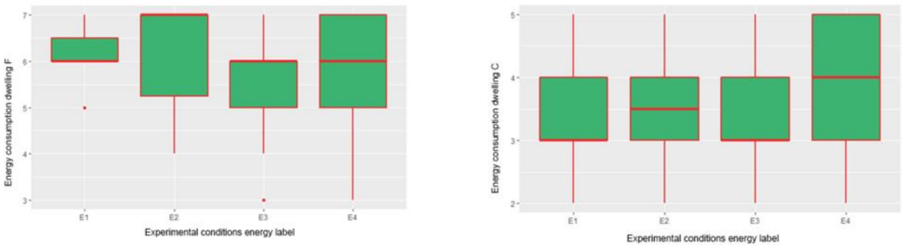


Figure 30 Energy label vs perceived energy consumption.
From left to right - 30a Dwelling labelled F; 30b Dwelling labelled C.
The box plots illustrate the lower quartile, the median and the upper quartile.

Energy label vs energy performance in comparison with the rest of the building stock

Previous subsections analysed responses given on an absolute scale, with dwellings compared to the most and the least energy-efficient dwelling imagined. This subsection analyses the comparisons with the rest of the building stock. Respondents estimated the percentage of the dwellings with a better label. The experimental conditions E2 and E4 contained this information implicitly in the form of the graph, since the required percentage was the sum of proportions accounted for by each energy class better than F (or C), see *Figure 26c* and *Figure 26d*.

Dwelling F

According to 2014 data of the certified residential dwellings 70 per cent of the dwellings have a better label than F (Verbeeck and Ceulemans, 2016). Respondents have underestimated this value in all the experimental conditions (mean estimation E1 - 59.4 per cent, E2 - 63.7 per cent, E3 - 60.61 per cent, E4 - 56.9 per cent), see *Figure 31a*. Yet, the results of one sample t-tests comparing the estimation with the actual value 70% are all significant except for E2 (rescale), see *Table 34*. The under-evaluation of the percentage of the dwellings with a better label implies an overly favourable assessment of the energy performance of the dwelling labelled F, relative to the rest of the housing stock.

The labels E2 and E4 include this information in the form of a graph, yet respondents did not make use of this information in their responses or were not able to interpret correctly the graph. This result is surprising giving the fact that 73.2 per cent of the sample has higher education. Previous results of the pilot test with students show that adding this information as plain text (percentage of the dwellings with a better label) is also not effective in correcting the wrong estimation, although students were better in interpreting the graph (Taranu et al., forthcoming 2018). With label E2 respondents estimate in a heuristic manner the percentage and this estimation is not significantly wrong.

Dwelling C

In the case of label C, 20 per cent of dwellings have a better label, according to 2014 data (Verbeeck and Ceulemans, 2016). Respondents did not estimate this value accurately, even for E3 and E4, in which the graph contained this information, see *Figure 26c* and *Figure 26d*. By contrast to dwelling F, the mean estimation for all experimental conditions was higher than the reality (E1 – 28.1 per cent, E2 – 31 per cent, E3 – 28.5 per cent, E4 – 32.1 per cent). According to one sample t-tests comparing estimation to the actual figure of 20 per cent, the estimation was significantly higher regardless of the experimental condition, see *Table 34*. Respondents either did not use or did not correctly interpret the table of experimental conditions E3 and E4.

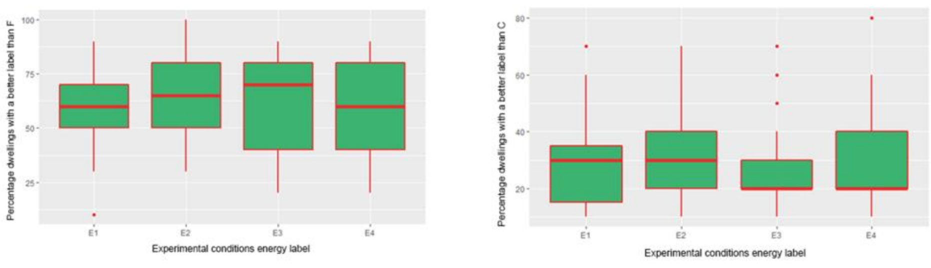


Figure 31 Energy label vs energy performance in comparison with the rest of the building stock. From left to right - 31a Dwelling labelled F; 31b Dwelling labelled C. The box plots illustrate the lower quartile, the median and the upper quartile.

Table 34 Energy label vs. estimated percentage of dwellings with a better label.

	Dwelling labelled F		*Dwelling labelled C*	
	t.test H0 mean diff (X-70) is equal to 0		*t.test H0 mean diff (X-20) is equal to 0*	
	t	*p-value*	*t*	*p-value*
Label E1	*-3.10*	*0.004***	*2.81*	*0.009***
Label E2	*-1.73*	*0.095*	*3.97*	*0.0004****
Label E3	*-2.51*	*0.017**	*3.44*	*0.002***
Label E4	*-3.13*	*0.0041***	*3.65*	*0.001****
*Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05*				

Energy label vs perceived need for renovation

After the interpretation of the energy efficiency and energy consumption in absolute and relative terms, a series of questions surveyed the impact of the energy label on perceived required renovation and willingness to renovate.

Dwelling F

When presented with the question "*Do you think that this dwelling requires renovation in order to improve the energy efficiency?*" for dwelling labelled F, responses differed depending on the experimental conditions E, see *Figure 32*. The results of the ordinal logistic regression (Proportional-odds cumulative logit model) show that respondents presented with the experimental conditions E3 and E4 assessed a lower level of required renovation for dwelling F compared to control condition E1, see *Table 36*. These results are consistent with the previous findings about perceived energy efficiency of the dwelling F - adding the graph to the rescaled label (E4) contributed to a higher perceived energy efficiency of the label F, and thus to a more favourable assessment of the dwelling F and a lower perceived need for renovation. The graph contributed to assigning less extreme levels to dwelling F, even though in the rescaled version E4 label F was the worst label on the scale, see *Figure 26d*.

Another factor influencing the perceived need for renovation was the order in which the dwellings were presented. If presented after the label and recommendations of the dwelling C, respondents decided that dwelling F required deeper levels of renovation (ordinal logistic regression, p-value=0.03, see *Table 36*). Many respondents were surprised that the yellow label C still required such a long list of renovation measures. This contributed to an even less favourable assessment of the red label F when presented second.

Dwelling C

For dwelling C, respondents presented with experimental condition E2 assigned a deeper level of required renovation compared to the control condition E1, due to rescaling (see *Table 36*).

As in the case of dwelling labelled F, the order in which dwelling C was presented had an impact. If presented after dwelling F, a lighter renovation was perceived to be required for dwelling C (ordinal logistic regression, p-value=0.03, see *Table 36*). This is again an evidence of anchoring effect by contrast to the anchor, dwellings are being compared and are not assessed in absolute terms. This order effect is consistent with the order effect of the perceived energy efficiency where dwelling C was perceived more optimistic if presented second, see *Table 33*.

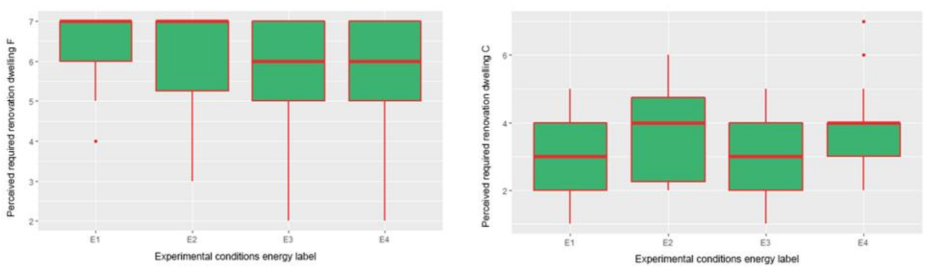


Figure 32 Energy label vs perceived need for renovation.
From left to right - 32a Dwelling labelled F; 32b Dwelling labelled C.
The box plots illustrate the lower quartile, the median and the upper quartile.

Table 35 Energy label vs. perceived required renovation. Results of the ANOVA tests.

	ANOVA Kruskal-Wallis		
	chi-squared	df	p-value
Dwelling F	7.56	3	0.056
Dwelling C	9.35	3	0.025*
Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05			

Table 36 Energy label vs perceived required renovation. Results of the ordinal logistic regression.

	Ordinal logistic regression[1] relative to control version Label 1		
	Energy labels/ effect	Estimate	p-value
Dwelling F	Label E3	0.98	0.04 *
	Label E4	0.98	0.046 *
	graph	0.98	0.04*
	Order effect FC-CF	-0.74	0.03 *
Dwelling C	Label E2	-1.01	0.03 *
	rescale	-1.01	0.03 *
	Order effect FC-CF	-0.70	0.03 *

[1]The complete results of Proportional-odds cumulative-logit model are presented in Attachments.

Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05

Energy label vs willingness to renovate

Dwelling F

The different designs of label E had an impact on stated willingness to renovate. This was measured with a binary question "If you were the owner of the dwelling, would you renovate it?". Results of the Pearson's Chi-squared test are significant for dwelling F (X squared=7.96, df=3, p-value= 0.047). The experimental condition E3 (graph, no rescale) resulted in a lower willingness to renovate, see *Figure 33a*. This result is consistent with a lower perceived energy efficiency of label F when the graph was present.

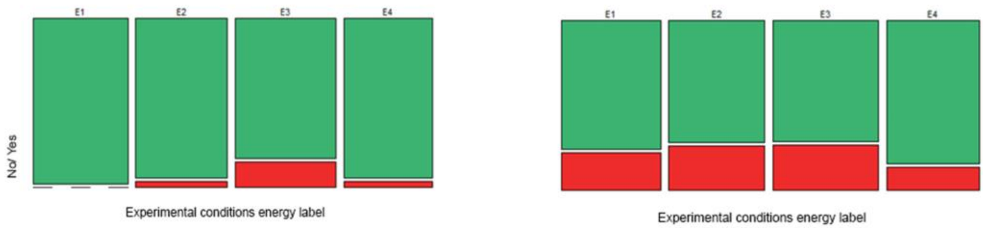


Figure 33 Energy label vs willingness to renovate.
From left to right - 33a Dwelling labelled F; 33b Dwelling labelled C.

Results of the study - Part 2 Recommendations

After the energy label of each dwelling, a page with recommendations followed, see *Figure 28*. Control condition (R1), which was the preliminary version provided by the Flemish Energy Agency, included an estimation of price, but did not include any benefits, see *Figure 28a*. The alternative experimental conditions included the benefits in terms of various framings – the label achieved after renovation (R2), monetary savings expressed as a percentage (R3) and CO_2 savings expressed as a percentage (R4).

Surprisingly, the addition of benefits in any of the above framings did not significantly increase the perceived required renovation or the willingness to renovate. One reason could be that the column with savings was not sufficiently salient. Yet, the column of the label employed colours and an illustration of the class achieved by following a group of recommendations, see *Figure 28b*. At the same time the information framing of the energy label, even with a modest change such as the rescale, had an impact on perceived need for renovation and willingness to renovate.

Even though the different experimental condition of the recommendation page did not play a role, the order in which the dwellings were presented did. If presented second, dwelling C is perceived to need a lighter level of renovation due to anchoring effect of the previous worse dwelling F (ordinal logistic regression, p-value=0.03, see *Table 36*).

Part 3 Size effect

The last question aimed to investigate if respondents understood that the label and the EPC score were expressed relative to the size of the dwelling. Participants were presented again with the first pages of the energy label of the two dwellings labelled F and C. The text of the question included information about the size of the dwellings as well as the EPC score. Dwelling F with an EPC score of 580 kWh/m^2 per year had a size of 100 m^2, meaning that the total annual energy was 58000 kWh. Thus was lower than dwelling C, with an EPC score of 230 kWh/m^2 per year and a size of 300 m^2, or 69000 kWh annually. Overall 61 per cent of respondents incorrectly chose dwelling F as having higher annual consumption, implying failure to understand that the label was relative to the size.

Half of the respondents were presented with experimental condition S2 that included the explanation about the size effect and the total annual energy alongside the label and EPC score, see *Figure 27*. Nevertheless, this explanation did not significantly improve understanding of the size effect (Pearson's Chi-squared test X squared= 0.39, df=1, p-value=0.53). In S1, 64.5 per cent of participants produced incorrect answers, while in S2 the figure was 57.4 per cent. As in the case of appliances (Waechter et al., 2015b), dwellers focus only on the energy class and fail to appreciate the annual energy use.

Discussion and policy implications

The main finding is that the energy label on the energy performance certificate plays a more important role than the recommendations. Even a small change in the range of the scale of the label has an impact on the interpretation of the perceived energy efficiency of labels F and C and the required renovation. With the rescaled version, G to A+ (600 to -100 kWh/m^2 per year) instead of the initial working version F to A (700 to 0 kWh/m^2 per year) estimated energy efficiency is perceived to be lower.

With the rescaled version respondents could estimate correctly dwellings labelled F in comparison with the rest of the building stock. With initial scale F to A homeowners were underestimating the percentage of dwellings with a better label than F. Rescaling contributes to correcting this bias, while presenting the graph did not engage respondents in deliberative thinking or they could not interpret correctly the information on the graph. A correct estimation of the energy performance of dwellings labelled F relative to the rest of the dwelling stock could have important implications in purchase and renovation decisions. Also, with rescaled version F to A+ respondents estimated that dwelling C is less energy efficient and needs a higher level of renovation. As a result of these arguments, the Flemish Energy Agency has opted for the F to A+ version of the scale for the final certificate (Vlaamse overheid, 2018).

Results point out that respondents used the energy label as a shortcut to avoid engaging in deliberative processing of the rest of the information on the certificate. The experimental conditions of the energy label had an impact on the perceived need for renovation unlike the addition of benefits for recommended measures. Another result suggesting failure to engage in deliberative thinking is that presenting the total annual energy besides the energy class was not effective in making homeowners aware that the EPC score is relative to the size of the dwelling. These findings are consistent with previous studies regarding energy labels for appliances, that documented the 'energy-efficiency fallacy' – consumers focus only on the energy label and ignore other information such as total annual energy consumption (Waechter et al., 2015b). Lack of comprehension that the EPC score is relative to the size of the dwelling provides evidence of bounded rationality when trying to comprehend efficiency metrics, similarly to difficulty comprehending the miles per gallon unit of fuel efficiency for vehicles (Larrick and Soll, 2008).

There was a similar lack of impact of the savings outlined on the recommendations page. Any framing of the benefits of the recommendations such as label achieved, monetary or CO_2 savings did not significantly affect the perceived required renovation and willingness to renovate. This finding is potentially important, because many information campaigns rely heavily on presenting a list of recommendations and their savings, mostly in monetary terms. The same occurs with the building passport, a novel policy instrument under development in some EU countries, including Belgium (Fabbri et al., 2016). The building passport is an online extension of the existing EPC, with more detailed information about renovation scenarios. Both information campaigns and building passports are designed based on the assumption that energy savings play a role in decision making and that homeowners are willing and able to process the associated technical information. While the present experiment does not show that these interventions are likely to be ineffective, it does cast doubt on whether homeowners can process this information meaningfully. Consequently, this study adds weight to arguments for using behavioural scientific methods to pre-test interventions.

Nevertheless, the energy label and the order in which the dwellings were presented played a bigger role in perceived need for renovation and the willingness to renovate than presenting the energy savings associated with the recommended measures. The anchoring effect is a strong one, comparing different dwellings contribute to "recalibrating" the scale of the label. Similarly, other studies show that squares are rated bigger if a small square is presented as an anchor, or a certain sales commission is perceived to be higher if associated with those earning less (Sarris and Parducci, 1978). The anchoring effect helps to explain why dwelling F was perceived to need a deeper level of renovation if presented after dwelling C. Besides, homeowners appear to have low awareness of different degrees of possible renovation and not to appreciate that even average dwellings such as the ones labelled C still need a quite deep level of renovation. Presenting dwelling C first, could have contributed to a "recalibration" of the scale. Given this anchoring effect, instead of focusing on a list of recommendations, the building passport and the information sessions could present different scenarios of renovations of average dwellings and of very inefficient dwellings.

The current research is an example of how policy making agencies can collaborate with researchers in elaborating evidence-based policies based on behavioural insights. The preliminary scale G to A was misinterpreted and had it been implemented, could have contributed to an overly favourable assessment of the most inefficient dwellings in comparison with the rest of the dwelling stock. On the other hand, one behaviourally informed intervention tested here, despite being based on initial focus groups and pilots, nevertheless backfired. This underlines the benefits of pre-testing policy instruments in controlled experiments in order to test how specific behaviourally informed interventions actually work in the particular intended context. Of course, the collaboration between policy agencies and researchers can delay the implementation of the policy tool. Yet, the previous version of the certificate in Flanders was developed ten years ago and the released EPCs will still be valid for another ten years from now. The long span over which such policies have an impact and the large scale on which they operate may justify the delay that can accompany collaboration with behavioural researchers. Most policies could perhaps be improved if tested before being scaled up, using laboratory and other kinds of experiments to isolate behavioural mechanisms and estimate their effects (Lunn and Choisdealbha, 2016). It is important to recognise too that this process can generate spillover effects, generating results that can be of use and guide policy development in other contexts. In the present context, improved comprehension and interpretation of the information presented on the EPC may contribute to better decision making in purchase and renovation decisions and, therefore, to improved efficacy of the certificate as a policy tool.

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Conclusions Part 2

How to communicate energy related information

System 1 interpretation of energy related information might contribute to sub-optimal decision making for consumers and ineffective information provision tools. Previous research has shown evidence of biased interpretation of energy metrics, such as the perceived linearity of miles per gallon (Larrick and Soll, 2008, Larrick et al., 2015). Another example regards the energy label of the appliances, the 'energy efficiency fallacy', when consumers focus only on the energy efficiency (e.g. class A), ignoring the information about annual electricity consumption (e.g., 100 kWh/year) (Waechter et al., 2015b).

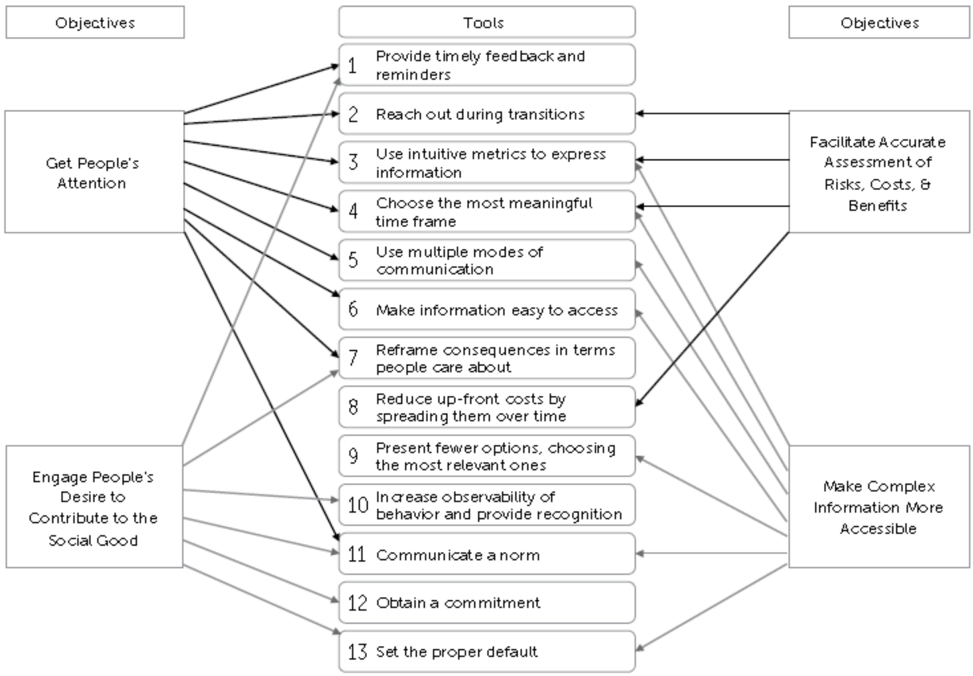

Figure 34 Framework how to communicate energy metrics. Retrieved from (Yoeli et al., 2017)

Yoeli E. et al. provide a framework on how to communicate energy metrics, see *Figure 34*, that is based on literature review of studies (Yoeli et al., 2017). Similarly, Larrick R.P. et.al. provide the framework CORE (Consumption Objectives Relative Expand) with the following guidelines in communicating energy related information, with emphasis on metrics (Larrick et al., 2015):

- "*Consumption: Provide consumption rather than efficiency information.*
- *Objectives: Link energy-related information to objectives that people value.*
- *Relative: Express information relative to meaningful comparisons.*
- *Expand: Provide information on expanded scales*."

Nevertheless, these frameworks are elaborated based on literature review of studies and cannot be used in other contexts without further testing. Certain guidelines could be contradictory such as longer time spans for communicating energy savings argued by "*choose the meaningful time frame*" (Yoeli et al., 2017) vs. shorter time spans motivated by present bias (BIT, 2011a).

The following insights regarding communicating energy metrics are provided based on our laboratory experiment findings in the context of the Flemish EPC:

- **Energy label** on the energy performance certificate plays a more important role than the **recommendations**, both in terms of assessing the energy performance of the dwelling, as well as the required renovation.
- Even a small change in the **range of the scale** of the label has an impact on the interpretation of the perceived energy efficiency of labels F and C and the required renovation of label C.
- Homeowners process the information of the certificate in a heuristic rather than deliberative way or they are not able to interpret the information correctly.

- Presented with the **graph** they could not estimate correctly the percentage of dwellings with a better label.
- Presenting the total annual energy besides the energy class was not effective in making homeowners aware that the EPC score is **relative to the size** of the dwelling.

- Lack of presenting or any framing of the benefits of the recommendations such as label achieved, monetary or CO_2 savings did not significantly affect the perceived required renovation and willingness to renovate.

- The order in which the dwellings were presented played a bigger role in perceived need for renovation and the willingness to renovate than presenting the energy savings associated with the recommended measures.

Information campaigns, EPCs and building passports (Fabbri et al., 2016) are designed based on the assumption that energy savings play a role in decision making and that homeowners are willing and able to process the associated technical information. The findings of the experiments challenge these assumptions. Given that the order in which the dwellings were presented played a bigger role than presenting the energy savings, the information campaigns could present different scenarios of renovations of average dwellings and of very inefficient dwellings.

At the same time, the addition of the graph (social norm) did not improve comprehension and interpretation of the label; it even backfired. Thus, findings from other cultural contexts and other policy contexts cannot be transformed into a list of recommended nudges.

Based on these results of laboratory experiments the new version of the Flemish EPC was rescaled from the initial G to A (700 to 0 kWh/m^2 per year) to F to A+ (600 to -100 kWh/m^2 per year) (Vlaamse overheid, 2018). The issue of the size-effect bias was still not addressed, since communicating the total energy as plain text, besides the energy label was not effective.

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Conclusions

Framework for elaborating evidence-based policies

Framework – Integrative method of elaborating BI policies

BE transposed evidence regarding dual-process thinking to economic contexts starting from '50 with Simon H. and its importance in the field of economics was acknowledged by awarding the Nobel Prize to Simon H. in 1978, to Kahneman D. in 2012 and to Thaler R. H. in 2017 (The Committee for the Prize in Economic Sciences in Memory of Alfred Nobel, 2017). These findings from DPMs and BE started to be influential among policy makers starting from 2009, with popularisation of the term 'nudge' by Thaler R. H. and Sunstein C.R. (Thaler and Sunstein, 2009), collaboration of Sunstein C.R. under President Obama administration from 2009 to 2012 (Sunstein, 2013) and the establishment of the Behavioural Insights Team as part of the UK government in 2010 (The Behavioural Insights Team, 2018). In the last decade the BI policies exponentially increased in many policy sectors, with over 196 behavioural insights units/initiatives across the world (Alain Samson (Ed.), 2018), many of which being governmental behavioural units. Besides national governments, the World Bank has launched Global Insights Initiative (GINI) (Alain Samson (Ed.), 2016) and the European Commission's Joint Research Centre and OECD have elaborated reports regarding BI policies (Lourenço et al., 2016, OECD, 2017, Lunn, 2013).

BE provided evidence regarding behavioural failures, deviations from the rational decision making previously assumed by the neoclassical economic theory, and can be classified in three categories (The Committee for the Prize in Economic Sciences in Memory of Alfred Nobel, 2017):

- Bounded rationality (cognitive limitations)

- Bounded willpower (self-control problems)
- Social preferences

Behaviourally-informed policies aim to address these behavioural failures, yet a mainstream misinterpretation is that BI policies are reduced to exclusively nudges, or libertarian paternalism (Lourenço et al., 2016). According to Sunstein C.R. "*a general principle of behaviourally informed regulation – its first and only law – is that the appropriate responses to behavioural market failures usually consist of nudges*" (Sunstein, 2013). Nudges and libertarian paternalism aim to steer the behaviour in a certain direction with slight changes in the choice architecture, without limiting the freedom to choose differently (Sunstein, 2013, Sunstein, 2014). Most of the studies test the efficiency of a certain nudge in a real world context by measuring revealed preferences with the use of RCTs (Haynes et al., 2012, BIT, 2017, Alain Samson (Ed.), 2017), this approach will be referred to as '**nudge vs. no nudge'**. Yet, this approach of elaborating BI policies has the following limitations:

- The strategy 'nudge vs. no nudge' implies that the behavioural reduction is done before the study therefore external constraints might be overseen by the policy makers (Baldwin, 2014b).

- The narrow focus on the bias ignores other aspects of DPMs, such as heterogeneity of the population and factors influencing the balance between system 1/system 2 thinking, with the risk to "*discriminate against the vulnerable parties*" (Baldwin, 2014b).

- RCTs provide evidence of the efficacy of the nudge in a particular context, without isolating and detecting the behavioural mechanism responsible, contrary to laboratory experiments (Lunn and Choisdealbha, 2016). Therefore, findings from RCTs in a certain policy field or in a certain socio-demographic and cultural context cannot be easily transposed to other contexts.

- The false dichotomy of nudge (soft-paternalism) vs. mandate (hard paternalism) (Sunstein, 2013, Sunstein, 2014) artificially excludes the possibility to apply behavioural insights to traditional policies, such as mandates and economic incentives.

Therefore the common practice in policy making is to address market failures with traditional policies based on neoclassical assumptions, while behavioural failures are addressed with BI policies such as nudging. Even though this narrow approach towards BI policies was mainstream in the last decades, (Bubb and Pildes, 2014) argue that behavioural failures interact with traditional market failures and cannot be addressed in isolation with the nudging approach. In the same line Bhargava S. and Loewenstein G. discuss that "*BE can and should now aspire to influence the design of policies aimed at deeper causes of policy problems" (Bhargava and Loewenstein, 2015)* and advocate for an integrative approach for BI policies.

The framework for elaborating BI policies proposed in this section aims a holistic way of applying behavioural insights to policy making, by including both explicit application of behavioural insights (nudges) and implicit use of evidence from DPMs for elaborating traditional policies. Moreover, decisions such as renovation are not affected only by the nudge; external barriers and facilitators, including a mix of existing policies play an important role. With a range of both qualitative and quantitative research methods, the full spectrum of policy measures can be analysed taking into account the assumptions of BE. The following framework is based on the previous research in the context of energy renovation, using the Flemish EPC as the case study for the behaviourally-informed policy, see *Figure 35*.

- Firstly, a general policy issue and behavioural change aim is individuated – in this case necessity to increase the energy renovation rates. The policy issue cannot be substituted with a sub-problem such as low response rates to information sessions regarding energy efficiency, since many other factors would remain neglected. The behavioural reduction in order to operationalise the scientific study will be done at a later stage.

- With literature review and focus groups with experts (including behavioural scientists) the following aspects of the issue are analysed:
  - External barriers and facilitators – capital availability, salient life events, home tenure, heterogeneity of the building stock.
  - Aspects of the choice architecture – bounded rationality, uncertainty of the renovation outcomes, awareness and motivation, lack of trusted sources of information.
- Existing and potential policy tools are individuated to address both aspects – external barriers and choice architecture. One policy measure is selected for further investigation, in this case the new version of the Flemish EPC.
- Taking into account all implementation aspects, one unaddressed issue is individuated, in this case the impact of the information framings on comprehension, interpretation of the certificate and on the willingness to renovate.
  - Potential biases and nudges are hypothesised based on DPMs and other studies in the field – social comparison, loss aversion, size-effect bias, salience.
  - Case studies of European EPCs in order to individuate a wide array of information framings and potential nudges – the hypotheses of the subsequent quantitative study.
  - A focus group with local experts in technical and behavioural aspects help to adapt to the local context and narrow down the hypotheses to be tested.

    - Trial tests of laboratory experiments further reduce the number hypotheses to be tested in laboratory experiment and detect existing biases and nudges to overcome or exploit the biases. RCTs are also possible as alternative method at this stage of the study.

    - Testing and validation of the behavioural mechanism using laboratory experiments with factorial design. Laboratory experiments were chosen over RCTs because the former allow to determine the behavioural mechanism besides determining which EPC version provides better results in achieving the goals of the policy tool.

- Application of the findings for modifying the policy tool. The Flemish EPC was rescaled from the initial G to A (700 to 0 kWh/m^2 per year) to F to A+ (600 to -100 kWh/m^2 per year). The issue of the size-effect bias was still not addressed, since communicating the total energy as plain text, besides the energy label was not effective.

- Application of the findings to the general mix of policies by reconsidering the assumptions and taking into account the behavioural aspects of the choice architecture already addressed.

The evidence from other cultural contexts cannot be easily replicated and up-scaled to other contexts (Jones et al., 2011), for example in the laboratory experiments with Flemish homeowners the social norm backfired. Another issue is to apply findings from other policy contexts - testing behavioural insights with RCTs with a list of nudges and biases implies too many hypotheses with little chance of success. Therefore, qualitative studies are necessary for each particular context, accounting for cultural and policy field differences.

The elaboration of BI policies should be an iterative process and the evidence from each study has to be integrated in updating the assumptions of the general mix of policies, see Figure 35. Behavioural insights tested in laboratory or field studies do not regard only nudges or information framing, but can be applied also in the choice between policy instruments and in their implementation. For example the European Commission recommends "*Member States should make* *use of concepts such as trigger points, namely opportune moments in the life cycle of a building, for example from a cost-effectiveness or disruption perspective, for carrying out energy efficiency renovation."* (EC, 2018) This recommendation is in line with the nudge "*make it timely*" from EAST framework (Hallsworth et al., 2014).

To avoid falling in the trap of comparing nudges to other policies with regard to cost-effectiveness, underlined by some promoters of libertarian paternalism (Benartzi et al., 2017), an integrative approach of applying behavioural insights to both soft and hard paternalistic measures is proposed. Certain nudge interventions can be more cost-effective but can still fail to address structural barriers, such as lack of access to capital (Jones et al., 2011). Besides, certain policy might be effective on short term, but it might fail to address major problems on the long run. For example, in a study regarding smart heating controls, Behavioural Insights Team concluded that these are more cost effective than wall insulation (BIT, 2017). Yet, only with curtailment measures, without encouraging investments in EE measures, climate goals of energy reduction can never be reached. Long-term policy goals to tackle core issues of energy renovation such as awareness and availability of capital can be achieved only with costly policy measures such as information campaigns, loan schemes and energy labels schemes. Yet, in order to reach their full potential, these have to be elaborated and implemented by taking into account behavioural insights.

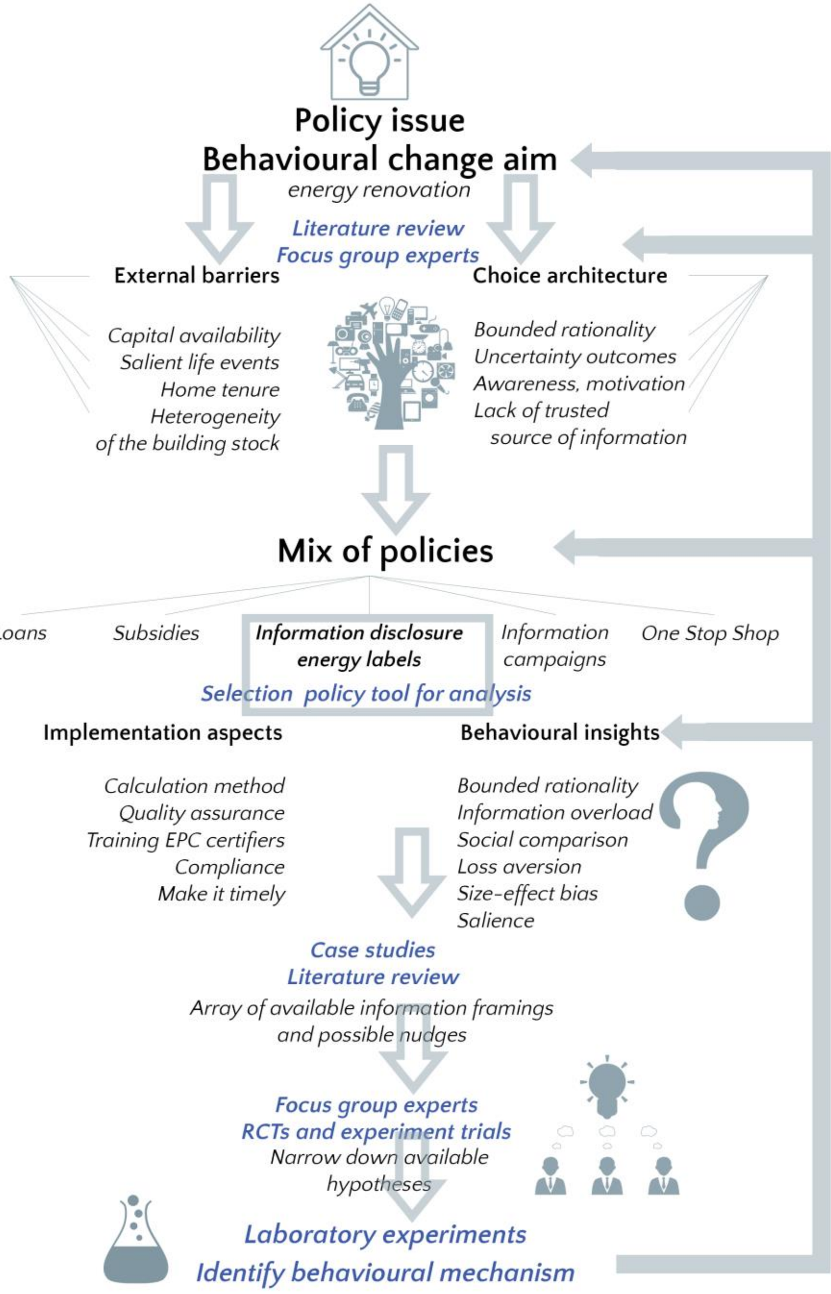

Figure 35 Framework Integrative method of elaborating BI policies. Based on energy renovation and the Flemish EPC case study.

Recommendations for policy makers for elaborating BI policies

- In order to elaborate evidence-based policies, the studies require rigour in the experimental design (for example factorial design is needed to determine the cause of a phenomenon) and data collection (for example sampling techniques). The study has to be designed in such way to serve two purposes – to inform the policy maker regarding the impact of the particular policy under investigation and to contribute to the field of knowledge for the future policies, for example by detecting the behavioural mechanism.

- In the choice between qualitative and quantitative research methods has to be taken into account that none is superior and they fit different purposes having different advantages and limitation. Usually a range of qualitative and quantitative methods are necessary at different stages of policy elaboration, see *Figure 35*. Even within quantitative methods there are alternative methods, fitting different purposes. In the context of BI policies, opposing schools of thought advocate for either field trials (RCTs) or laboratory experiments. Field trials have the advantage of bigger sample sizes and revealed preferences compared to stated preferences of laboratory experiments. Yet, the latter have the possibility to control and manipulate experimental conditions, with the possibility to isolate and detect the behavioural mechanism, allowing future applications for other policy contexts (Lunn and Choisdealbha, 2016).

- Findings, moreover in social sciences have to be interpreted taking into account the limitations of the research design. Studies on certain topics such as renovation decisions can be context dependent and findings from other countries can serve as clues for elaborating hypotheses but these have to tested in the particular cultural context. In the same line, behavioural insights from other policy fields should be applied with caution, some nudges such as social norm can even backfire, see Conclusions Part 2. Besides, statistical tests determine low or high likelihood of effects, depending heavily on the sample size and assumptions of the tests.

- BI policies require collaboration of researchers from various fields, moreover that in the field of energy studies the trend is shifting from a technical perspective to more emphasis on social sciences. SHAPE-ENERGY Platform ("Social Sciences and Humanities for Advancing Policy in European Energy") encourages collaboration of policy makers in the field of energy with researchers from the following disciplines – "*Business, Communication Studies, Demography, Development, Economics, Education, Environmental Social Science, Gender, History, Human Geography, Law, Philosophy, Planning, Politics, Psychology, Science and Technology Studies, Sociology, Social Anthropology, Social Policy, and Theology*" (Shape Energy Project, 2018). Various collaboration scenarios are possible, from direct involvement in the project and establishment of a behavioural unit to punctual consultations in formats such as focus groups, Delphy method, etc. The first BI policy elaborated is the most difficult because it requires capacity building and in cases of multiple BI policies governments sometimes opt for setting up a behavioural unit, such as Behavioural Insights Team in the UK in 2010 (The Behavioural Insights Team, 2018) or Behavioural Economics Unit under Sustainable Energy Unit of Ireland SEAI (Sustainable Energy Unit of Ireland SEAI, 2018). In the last decade over 196 behavioural insights units/initiatives were established across the world (Alain Samson (Ed.), 2018), many of which being governmental behavioural units or under international organisations.

- Setting up BI policies is time and resource consuming and might imply a slower elaboration and implementation of a certain policy. Nevertheless, the previous version of the certificate in Flanders was developed ten years ago and the released EPCs will still be valid for another ten years from now. The long span over which such policies have an impact and the large scale on which they operate may justify the delay that can accompany collaboration with behavioural researchers.

Limitations and directions for future research

Initially the intention was to study the deep energy renovation as a process, yet for purpose of the survey and the laboratory experiments, the renovation process has been operationalised as investments in EE measures. The renovation measures considered at achieving nZEB consisted in EE and RE measures on site, ignoring embodied energy and life cycle approach, yet this is the most commonly used calculation method (Marszal et al., 2011, IPEEC, 2018). Sufficiency design strategies and more innovative technologies (such as integrated PV and solar water heater systems or water recycling systems) could be part of future research, especially in the view of comparing them to more traditional and widespread EE measures.

The interdisciplinary character of the present research aims to integrate insights from two bodies of knowledge – BE and energy renovation policies. These, at their turn, constitute an integration of several disciplines – psychology and economics for the former and social sciences, humanities and STEM (Science, Technology, Engineering and Mathematics) disciplines for the latter (Shape Energy Project, 2018). As any interdisciplinary study, the present research lacks the rigour and depth characteristic to each research field in isolation. This limitation was addressed by tight collaboration with economists, statisticians, architects and behavioural scientists, who are the co-authors of the chapters.

From the point of view of behavioural study, the individual characteristics such as need for closure, need for cognition and need for affect were not measured during the survey and laboratory experiments. To complete the items of these three scales would imply considerable additional time for respondents, yet the segregation of the sample according to these characteristics could provide useful insights regarding asymmetric impact of the BI policies and their potential "*discrimination against vulnerable parties*" (Baldwin, 2014b). Another behavioural aspect that has not been analysed was the deviations from the *homo* *economicus* decision making due to fairness, solidarity, moral commitments (Posner and Sunstein, 2017). These aspects are interesting in the light of conflicts between present and future generations (Böhm et al., 2018) and fuel poverty and could be investigated in the context of communicating energy renovation and climate change.

Another limitation of the current approach consists in belonging to the school of thought of Heuristics and Biases (H&B) of Tversky A. and Kahneman D. (Tversky and Kahneman, 1974), as opposed to the school of thought of simple heuristics (SH) of Gigerenzer G. (Todd and Gigerenzer, 2007), ontological distinction underlined by Yanoff in explaining the difference between nudge and boost policies (Grüne-Yanoff et al., 2016). Boost approach, as opposed to nudging aims to improve individual competences, including with educative efforts. The potential of boosting can be further investigated in the context of energy renovation and could provide added value to the proposed framework in *Figure 35*.

Given the evidence of bounded rationality and suboptimal decision making, a fair critique to libertarian paternalism regards questioning the commitment to freedom of choice (Bubb and Pildes, 2014). Often libertarian paternalist interventions shift the responsibility from the welfare state to individuals. More research is needed in analysing the efficacy of nudges compared to mandates and subsidies, since previous studies focus on the 'nudge vs. no nudge' approach. The integrative framework aims at considering all policy options, without artificially truncating the policy issue. Yet, this approach is more difficult to operationalise in terms of evidence-based policy compared to the RCT testing the efficacy of the nudge in isolation. Therefore the debate should move from nudge vs. mandate, towards *how* traditional policies are elaborated and implemented, when even slight details such as energy metrics play a role (Larrick and Soll, 2008). Finally, the role of the policy maker should not be seen only as a nudger, but also as a regulator of other potential nudgers, such as economic agents.

Environmental policies to tackle climate change have achieved important advancements in the recent decades, yet these fall short given the urge to curb down CO_2 emissions in order to achieve COP21 goals (United Nations, 2015) and to achieve a decarbonised building stock in the EU by 2050 (EC, 2016). BI could contribute to a higher impact of the allocated resources and efforts, since BE challenged the assumptions of neoclassical economics and made important advancements towards "*re-humanising the decision-making process*" (Jones et al., 2011). Nevertheless, BI policies are still at an early stage, both the assumptions and the methods used for elaborating policies are yet to be revised and this thesis is a small step in this direction.

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Attachments

Attachments Chapter 2 – survey

Beste deelnemer,

Deze vragenlijst maakt deel uit van een **onderzoeksproject van de Universiteit Hasselt** (door Victoria Taranu, o.l.v. Prof. Griet Verbeeck) over het renoveren van woningen met het oog op energiebesparingen. De verworven data zullen uitsluitend voor onderzoeksdoeleinden worden gebruikt en anoniem worden verwerkt.

Bedankt voor uw deelname!

Met vriendelijke groeten,

Victoria Taranu

Q 0.1 Gelieve uw geslacht aan te duiden.

- ❍ Man
- ❍ Vrouw

Q 0.2 Wat is uw leeftijd (in jaar)? Vul aan in cijfers.

0.3 Gelieve uw woningtype aan te duiden.

- ❍ Huis
- ❍ Appartement

Q 0.4 Met hoeveel personen woont u samen, inclusief uzelf? Vul aan in cijfers.

Q 0.5 Hoeveel gezinsleden zijn tewerkgesteld, inclusief uzelf? Vul aan in cijfers.

Q 0.6 Wat is uw hoogst behaalde diploma

- ❍ Lager onderwijs
- ❍ Lager middelbaar
- ❍ Hoger middelbaar
- ❍ Hoger onderwijs
- ❍ Overige ______________________

Q 0.7 Bent u eigenaar of huurder van de woning?

- ❍ Eigenaar
- ❍ Huurder

Indien u eigenaar hebt gekozen, ga dan verder naar vraag ***Q 0.71***

Indien u huurder hebt gekozen, ga dan verder naar vraag ***Q 1.11***

Q 0.71 Wanneer kocht u uw woning? Gelieve het jaartal in te vullen.

Q 0.72 Wat is (bij benadering) het bouwjaar van uw woning?

Q 0.8 Heeft u ooit de woning die u bewoond hebt of nu bewoont gerenoveerd?

- ❍ Ja (ga verder naar Q 0.81)
- ❍ Neen (ga verder naar Q 0.9)

Q 0.81 Wanneer vond de renovatie plaats?

- ❍ > 10 jaar geleden
- ❍ 5-10 jaar geleden
- ❍ In de laatste 5 jaar
- ❍ Bezig met renoveren

Q 0.9 Bent u van plan uw huis in de komende 5 jaar te renoveren?

- ❍ Ja
- ❍ Neen

Muurisolatie

Q 1.1 Zijn uw muren geïsoleerd?

- ❍ Ja (ga verder naar vraag Q1.13, sla vragen Q1.11 en Q1.12 over)
- ❍ Neen (ga verder naar vraag Q1.11, sla vragen Q1.13 en Q1.23 over)

In de volgende reeks vragen dient u 4 stellingen te rangschikken. De eerste plaats kent u toe aan de stelling waar u het meest mee akkoord bent. De laatste plaats kent u toe aan de stelling waar u het minst mee akkoord bent. Op dezelfde plaats rangschikken is niet mogelijk.

Q 1.11 Ik zou muurisolatie plaatsen, omdat ...

_______ ik in een warm en comfortabel huis wil wonen
_______ ik geld wil besparen op verwarming
_______ het goed is voor het milieu
_______ iedereen zijn woning isoleert

Q1.21 Ik zou geen muurisolatie plaatsen, omdat ...

_______ mijn huis mooi is zoals het nu is
_______ ik verkies mijn geld uit te geven aan het interieur
_______ het geen groot verschil uitmaakt, mijn uitgaves voor energie zijn niet hoog
_______ het is te duur

Q 1.13 Ik heb muurisolatie geplaatst, omdat ...

_______ ik in een warm en comfortabel huis wil wonen
_______ ik geld wil besparen op verwarming
_______ het goed is voor het milieu
_______ iedereen zijn woning isoleert

Q 1.23 Ondanks dat ik mijn muren geïsoleerd heb, deden de volgende redenen mij daaraan twijfelen:

_______ mijn huis is mooi zoals het nu is
_______ ik verkies mijn geld uit te geven aan het interieur
_______ het geen groot verschil uitmaakt, mijn uitgaves voor energie zijn niet hoog
_______ het is te duur

Q 1.2 Zijn uw ramen energiebesparend?

- ❍ Ja (ga verder naar vraag Q 2.13, sla vragen Q 2.11 en Q 2.12 over)
- ❍ Neen (ga verder naar vraag Q 2.11, sla vragen Q 2.13 en Q 2.23 over)

Gelieve de stellingen als volgt te rangschikken: 1ste plaats: meest mee akkoord 4de plaats: minst mee akkoord

Q 2.11 Ik zou energiebesparende ramen plaatsen, omdat ...

_______ ik geld wil besparen op verwarming
_______ een vriend die deze geplaatst heeft mij dit aanraadt
_______ het goed is voor het milieu om energie te besparen
_______ al mijn buren hun ramen vervangen hebben

Q 2.21 Ik zou geen energiebesparende ramen plaatsen, omdat ...

_______ het te duur is
_______ mijn ramen nog goed zijn
_______ de subsidies te klein zijn/ er is geen financiële steun
_______ het te lang duurt voordat de investering zichzelf terugbetaalt

Q 2.13 Ik heb energiebesparende ramen geplaatst, omdat ...

_______ ik geld wil besparen op verwarming
_______ een vriend die deze geplaatst heeft mij dit aanraadt
_______ het goed is voor het milieu om energie te besparen
_______ al mijn buren hun ramen vervangen hebben

Q 2.23 Ondanks dat ik energiebesparende ramen geplaatst heb, deden de volgende redenen mij daaraan twijfelen:

_______ het te duur is
_______ mijn ramen nog goed zijn
_______ de subsidies te klein zijn/ er is geen financiële steun
_______ het te lang duurt voordat de investering zichzelf terugbetaalt

Q 1.3 Bent u in het bezit van een energiezuinige ketel

- ❍ Ja (ga verder naar vraag Q 3.13, sla vragen Q 3.11 en Q 3.12 over)
- ❍ Neen (ga verder naar vraag Q 3.11, sla vragen Q 3.13 en Q 3.23 over)

Gelieve de stellingen als volgt te rangschikken: 1ste plaats: meest mee akkoord 4de plaats: minst mee akkoord

Q 3.11 Ik zou een energiezuinige ketel installeren, omdat …

______ ik geld wil besparen
______ een vriend die deze geplaatst heeft mij dit aanraadt
______ het goed is voor het milieu om energie te besparen
______ het me trots doet voelen

Q 3.21 Ik zou geen energiezuinige ketel installeren, omdat …

______ het te duur is
______ mijn huidige boiler wel meer verbruikt, maar nog steeds goed werkt
______ ik de energielabels niet goed begrijp
______ ik het geld liever besteed aan het interieur van mijn woning

Q 3.13 Ik heb een energiezuinige ketel geïnstalleerd, omdat …

______ ik geld wil besparen
______ een vriend die deze geplaatst heeft mij dit aanraadt
______ het goed is voor het milieu om energie te besparen
______ het me trots doet voelen

Q 3.23 Ondanks dat ik een energiezuinige ketel geïnstalleerd heb, deden de volgende redenen mij daaraan twijfelen:

______ het te duur is
______ mijn huidige boiler wel meer verbruikt, maar nog steeds goed werkt
______ ik de energielabels niet goed begrijp
______ ik het geld liever besteed aan het interieur van mijn woning

Q 1.4 Bent u in het bezit van zonnepanelen?

- ❍ Ja (ga verder naar vraag Q 4.13, sla vragen Q 4.11 en Q 4.12 over)
- ❍ Neen (ga verder naar vraag Q 4.11, sla vragen Q 4.13 en Q 4.23 over)

Gelieve de stellingen als volgt te rangschikken: 1ste plaats: meest mee akkoord 4de plaats: minst mee akkoord

Q 4.11 Ik zou zonnepanelen installeren, omdat ...

_______ het een goede investering is
_______ ik mijn inzet wil tonen tegenover het milieu
_______ al mijn buren het hebben laten plaatsen
_______ waarom fossiele brandstoffen verbranden wanneer je onbeperkte energie kan krijgen van de zon?

Q 4.22 Ik zou geen zonnepanelen installeren, omdat ...

_______ de subsidies zijn te laag of zijn afwezig
_______ mijn huis zou er minder mooi uitzien nadien
_______ het is te duur

_______ een vriend een slechte ervaring had met het installeren van zonnepanelen

Q 4.13 Ik heb zonnepanelen geïnstalleerd, omdat ...

_______ het een goede investering is
_______ ik mijn inzet wil tonen tegenover het milieu
_______ al mijn buren het hebben laten plaatsen
_______ waarom fossiele brandstoffen verbranden wanneer je onbeperkte energie kan krijgen van de zon?

Q 4.23 Ondanks dat ik zonnepanelen geïnstalleerd heb, deden de volgende redenen mij daaraan twijfelen:

_______ de subsidies zijn te laag of zijn afwezig
_______ mijn huis zou er minder mooi uitzien nadien
_______ het is te duur
_______ een vriend een slechte ervaring had met het installeren van zonnepanelen

Q 1.5 Bent u in het bezit van een zonneboiler?

- ❍ Ja (ga verder naar vraag Q 5.13, sla vragen Q 5.11 en Q 5.12 over)
- ❍ Neen (ga verder naar vraag Q 5.11, sla vragen Q 5.13 en Q 5.23 over)

Gelieve de stellingen als volgt te rangschikken: 1ste plaats: meest mee akkoord 4de plaats: minst mee akkoord

Q 5.11 Ik zou een zonneboiler installeren, omdat …

_______ het goed is voor het milieu om energie te besparen
_______ ze veel goedkoper zijn dan zonnepanelen
_______ al mijn buren een zonneboiler hebben laten plaatsen
_______ het rendabel is

Q 5.21 Ik zou geen zonneboiler installeren, omdat …

_______ het te moeilijk is om te installeren: vuil, rommel
_______ het te duur is
_______ ik niet veel weet van de voor- en nadelen

_______ een vriend een slechte ervaring had met het installeren/gebruiken van een zonneboiler

Q 5.13 Ik heb een zonneboiler geïnstalleerd, omdat …

_______ het goed is voor het milieu om energie te besparen
_______ ze veel goedkoper zijn dan zonnepanelen
_______ al mijn buren een zonneboiler hebben laten plaatsen
_______ het rendabel is

5.23 Ondanks dat ik een zonneboiler geïnstalleerd heb, deden de volgende redenen mij daaraan twijfelen:

_______ het te moeilijk is om te installeren: vuil, rommel
_______ het te duur is
_______ ik niet veel weet van de voor- en nadelen
_______ een vriend een slechte ervaring had met het installeren/gebruiken van een zonneboiler

Q 1.6 Bent u van plan om in energiebesparende maatregelen te investeren in uw huis in de komende 5 jaar?

- ❍ Ja
- ❍ Neen

universiteit hasselt
KNOWLEDGE IN ACTION

Beeld u in dat u eigenaar bent van een middelgrote woning in Vlaanderen en u een keuze moet maken uit 4 verschillende energiebesparende maatregelen, zijnde:

ramen, isolatie, verwarming, en hernieuwbare energie-installatie

Kies de optie die uw voorkeur wegdraagt.
Hieronder kan u een voorbeeldvraag terugvinden.

Voorbeeld

Als u wilt renoveren met een beperkt budget, welke van de volgende renovatiemaatregelen zou u kiezen?

	Ramen Isolerende beglazing	Isolatie Dak- en muurisolatie	Verwarmingssysteem Warmtepomp	Hernieuwbare energie Zonnepanelen
Uitzicht woning verandert	in beperkte mate	in beperkte mate	drastisch	drastisch
Niveau thermisch comfort	hoog	hoog	laag	laag
CO2 reductie	75%	50%	50%	75%
Kostprijs	€ 12 000	€ 12 000	€ 12 000	€ 8 000
Hinder tijdens renovatie	laag	hoog	laag	hoog
O.b.v. advies van	professional	vriend	geen advies	geen advies
	☐	☐	☐	☐

Op de volgende pagina's krijgt u nog 4 van dergelijke vragen. Elke vraag dient onafhankelijk van elkaar te worden beantwoord. Het antwoord op een vraag heeft dus geen gevolgen voor een volgende vraag.

Hieronder kan u de beschrijving van de kenmerken terugvinden.

Kenmerken	Beschrijving
Impact op het uitzicht van het huis	De impact op het uitzicht van het huis geeft weer in welke mate het uitzicht van het huis zal veranderen door de voorgestelde renovatie
Impact op het thermisch comfort	De impact op het thermisch comfort geeft weer in welke mate het thermisch comfort (aangename binnentemperatuur, geen tocht) zal verbeteren door de renovatie.
Vermindering in CO2	De vermindering in CO2 geeft weer hoeveel CO2 er minder wordt uitgestoten indien de renovatie wordt doorgevoerd.
Kostprijs (€)	De kostprijs is de som van de aankoop- en installatiekosten van de voorgestelde renovatie voor een middelgrote woning in Vlaanderen. De total investeringskost is exclusief steunmaatregelen.
Mate van hinder tijdens de werken	De mate van hinder tijdens de werken geeft de mate van ongemak (zoals lawaai, koude, vuil, onbeschikbaarheid ruimte, …) tijdens de renovatiewerken weer die u zal hebben indien de voorgestelde renovatie wordt doorgevoerd.
Bron van advies	De bron van advies geeft weer wie u het doorvoeren van deze maatregel heeft aangeraden

6.1 Als u wilt renoveren met een beperkt budget, welke van de volgende renovatiemaatregelen zou u kiezen?

Keuzesituatie 1

	Ramen Isolerende beglazing	Isolatie Dak- en muurisolatie	Verwarmingssysteem Warmtepomp	Hernieuwbare energie Zonnepanelen
Uitzicht woning verandert	in beperkte mate	drastisch	drastisch	drastisch
Niveau thermisch comfort	hoog	hoog	hoog	laag
CO2 reductie	75%	25%	50%	50%
Kostprijs	€ 12 000	€ 12 000	€ 12 000	€ 6 000
Hinder tijdens renovatie	laag	hoog	hoog	hoog
O.b.v. advies van	vriend	professional	geen advies	geen advies
	☐	☐	☐	☐

Overweegt u om deze maatregel met deze kenmerken ook effectief uit te voeren voor uw woning?

❍ Ja
❍ Neen

Q 7.1 Let op, de vraag is veranderd. Gelieve de vraag onafhankelijk van uw antwoord op de vorige vraag in te vullen. Als u wilt renoveren met een beperkt budget, welke van de volgende renovatiemaatregelen zou u kiezen?

Keuzesituatie 2

	Ramen Isolerende beglazing	Isolatie Dak- en muurisolatie	Verwarmingssysteem Warmtepomp	Hernieuwbare energie Zonnepanelen
Uitzicht woning verandert	drastisch	drastisch	in beperkte mate	drastisch
Niveau thermisch comfort	laag	laag	hoog	hoog
CO2 reductie	75%	50%	75%	25%
Kostprijs	€ 10 000	€ 8 000	€ 16 000	€ 6 000
Hinder tijdens renovatie	laag	hoog	hoog	hoog
O.b.v. advies van	professional	professional	geen advies	vriend
	☐	☐	☐	☐

Overweegt u om deze maatregel met deze kenmerken ook effectief uit te voeren voor uw woning?

- ❍ Ja
- ❍ Neen

Q 8.1 Let op, de vraag is veranderd. Gelieve de vraag onafhankelijk van uw antwoord op de vorige vraag in te vullen. Als u wilt renoveren met een beperkt budget, welke van de volgende renovatiemaatregelen zou u kiezen?

Keuzesituatie 3

	Ramen Isolerende beglazing	**Isolatie Dak- en muurisolatie**	**Verwarmingssysteem Warmtepomp**	**Hernieuwbare energie Zonnepanelen**
Uitzicht woning verandert	in beperkte mate	in beperkte mate	drastisch	in beperkte mate
Niveau thermisch comfort	laag	laag	laag	hoog
CO_2 reductie	50%	75%	50%	75%
Kostprijs	€ 12 000	€ 12 000	€ 16 000	€ 8 000
Hinder tijdens renovatie	laag	hoog	hoog	laag
O.b.v. advies van	geen advies	geen advies	geen advies	vriend
	☐	☐	☐	☐

Overweegt u om deze maatregel met deze kenmerken ook effectief uit te voeren voor uw woning?

❍ Ja
❍ Neen

Q 9.1 Let op, de vraag is veranderd. Gelieve de vraag onafhankelijk van uw antwoord op de vorige vraag in te vullen. Als u wilt renoveren met een beperkt budget, welke van de volgende renovatiemaatregelen zou u kiezen?

Keuzesituatie 4

	Ramen Isolerende beglazing	**Isolatie Dak- en muurisolatie**	**Verwarmingssysteem Warmtepomp**	**Hernieuwbare energie Zonnepanelen**
Uitzicht woning verandert	in beperkte mate	drastisch	drastisch	in beperkte mate
Niveau thermisch comfort	hoog	laag	hoog	laag
CO2 reductie	75%	75%	25%	25%
Kostprijs	€ 8 000	€ 12 000	€ 16 000	€ 8 000
Hinder tijdens renovatie	hoog	laag	laag	laag
O.b.v. advies van	geen advies	vriend	professional	professional
	☐	☐	☐	☐

Overweegt u om deze maatregel met deze kenmerken ook effectief uit te voeren voor uw woning?

- ❍ Ja
- ❍ Neen

Q 10 Wat waren de kenmerken die uw keuze het meest beïnvloed hebben? Indien uw keuze gebaseerd is op de afweging van alle kenmerken, mag u ze alle 6 aanduiden.

- ❑ Uitzicht woning verandert
- ❑ Niveau thermisch comfort
- ❑ CO2 reductie
- ❑ Kostprijs
- ❑ Hinder tijdens renovatie
- ❑ O.b.v. advies

Q 11 Kan u meedelen waarom u geen enkele van de voorgestelde maatregelen wil uitvoeren voor uw woning?

Q 99 Indien u kans wenst te maken om een Nespresso koffiezetapparaat te winnen, vul dan aub hieronder uw e-mail adres in. (Uw e-mail adres zal uitsluitend worden gebruikt om de winnaar te contacteren.)

____

Attachments Chapter 5 – questionnaire laboratory experiment

De volgende vragen gaan over pagina 1.
Woning 1
Gelieve het nummer in de rechter bovenhoek van de pagina in te vullen.

>>

Hoe energie-efficiënt is deze woning volgens u?

zeer inefficiënt	inefficiënt	minder dan gemiddeld	gemiddeld	boven het gemiddelde	efficiënt	zeer efficiënt

>>

Hoeveel energie zou volgens u een gemiddeld Vlaams gezin verbruiken als zij in dit huis wonen?

heel weinig	weinig	minder dan gemiddeld	gemiddeld	boven het gemiddelde	veel	heel veel

>>

Hoeveel andere woningen in Vlaanderen hebben volgens u een beter energielabel dan dit huis?

procent %

0 10 20 30 40 50 60 70 80 90 100

>>

Denkt u dat deze woning een renovatie nodig heeft om zijn energieprestatie te verbeteren?

1 geen renovatie	2 ...	3 ...	4 een redelijke renovatie	5 ...	6 ...	7 een zeer grondige renovatie

>>

Indien u de eigenaar zou zijn, zou u de woning effectief renoveren om zijn energie-efficiëntie te verbeteren?

ja omdat...

neen, omdat...

Attachments Chapter 5 – Results ordinal logistic regression

Energy label vs. perceived energy efficiency

Dwelling F

Table 37 Perceived energy efficiency for dwelling F.
Results of Proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	-0.4737	0.3830	-1.237	0.21613
(Intercept):2	1.1904	0.4007	2.971	0.00297 **
(Intercept):3	1.6223	0.4218	3.846	0.00012 ***
(Intercept):4	2.0493	0.4530	4.523	6.09e-06 ***
(Intercept):5	4.5594	1.0547	4.323	1.54e-05 ***
QE2	1.4673	0.5423	2.706	0.00682 **
QE3	-0.3321	0.4613	-0.720	0.47155
QE4	0.1146	0.4808	0.238	0.81163
ORDER CF	0.2765	0.3499	0.790	0.42943

*Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05*

Dwelling C

Table 38 Perceived energy efficiency for dwelling F.
Results of Proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	-6.4192	1.1077	-5.795	6.83e-09 ***
(Intercept):2	-4.7544	0.6460	-7.359	1.85e-13 ***
(Intercept):3	-3.8860	0.5492	-7.076	1.49e-12 ***
(Intercept):4	-1.7014	0.4333	-3.927	8.61e-05 ***
(Intercept):5	1.1885	0.4259	2.791	0.005259 **
(Intercept):6	3.9058	1.0515	3.715	0.000204 ***
QE2	1.3586	0.5089	2.670	0.007596 **
QE3	0.1621	0.4906	0.330	0.741122
QE4	1.4628	0.5144	2.844	0.004461 **
ORDER CF	1.0657	0.3612	2.950	0.003176 **

*Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05*

Energy label vs. perceived energy consumption

Dwelling F

Table 39 Perceived energy consumption for dwelling F. Results of Proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	-2.8407	0.5096	-5.574	2.49e-08 ***
(Intercept):2	-1.9788	0.4281	-4.622	3.79e-06 ***
(Intercept):3	-0.6947	0.3783	-1.836	0.0663 .
(Intercept):4	0.6587	0.3773	1.746	0.0809 .
QE2	-0.8757	0.4880	-1.794	0.0728 .
QE3	0.6404	0.4544	1.409	0.1588
QE4	0.3377	0.4683	0.721	0.4709
ORDER CF	-0.2544	0.3322	-0.766	0.4439

Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05

Dwelling C

Table 40 Perceived energy consumption for dwelling C. Results of Proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	-2.0125	0.4769	-4.220	2.45e-05 ***
(Intercept):2	0.9531	0.4009	2.377	0.0175 *
(Intercept):3	2.5521	0.4592	5.558	2.73e-08 ***
QE2	-0.4977	0.4903	-1.015	0.3100
QE3	-0.2042	0.4815	-0.424	0.6715
QE4	-1.1727	0.4961	-2.364	0.0181 *
ORDER CF	-0.6102	0.3451	-1.768	0.0771 .

Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05

Energy label vs. perceived need for renovation

Dwelling F

Table 41 Perceived need for renovation for dwelling F. Results of Proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	– 3.690256	0.618954	-5.962	2.49e-09 ***
(Intercept):2	– 2.952006	0.509163	-5.798	6.72e-09 ***
(Intercept):3	-1.841310	0.426625	-4.316	1.59e-05 ***
(Intercept):4	-1.150878	0.403024	-2.856	0.0043 **
(Intercept):5	0.006095	0.388797	0.016	0.9875
QE2	0.114818	0.502217	0.229	0.8192
QE3	0.982501	0.477302	2.058	0.0395 *
QE4	0.982646	0.491968	1.997	0.0458 *
ORDER CF	-0.742101	0.342722	-2.165	0.0304 *

Significance ***p-value < 0.001; **p-value < 0.01; *p-value < 0.05

Dwelling C

Table 42 Perceived need for renovation for dwelling F. Results of Proportional-odds cumulative-logit model.

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept):1	-2.8455	0.5911	-4.814	1.48e-06 ***
(Intercept):2	-0.2128	0.3715	-0.573	0.56675
(Intercept):3	1.0399	0.3830	2.715	0.00662 **
(Intercept):4	2.7506	0.4540	6.058	1.38e-09 ***
(Intercept):5	4.5887	0.6943	6.609	3.88e-11 ***
(Intercept):6	5.7125	1.0701	5.338	9.39e-08 ***
QE2	-1.0086	0.4701	-2.145	0.03193 *
QE3	0.1801	0.4535	0.397	0.69129
QE4	-0.7505	0.4703	-1.596	0.11051
ORDER CF	-0.7046	0.3310	-2.129	0.03329 *