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Are Dutch residents ready for a more stringent policy to enhance the energy performance of their homes?

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ABSTRACT

Investments in the energy performance of houses offer good prospects for reducing energy consumption and CO_2 emissions. However, people are not easily convinced of the need to take measures to improve the energy performance of their houses, even when financial benefits outweigh the costs. This article analyses the factors that influence the decision for improving the energy performance of existing homes, including policy instruments. Subsequently, the article provides policy suggestions on how to stimulate energy performance improvements. Both owners and tenants (50–70%) support government policy on energy performance improvements to existing homes. Nevertheless, people also have strong feelings of autonomy regarding their homes. Our results underline the importance of well-informed and competent decision-makers. Introducing the use of Energy Performance Certificates (EPCs) into the tax system for energy and residential buildings might therefore be an effective way to increase the interest of owners in the EPC, improve the use and effect of this informative instrument, and make the first step towards bridging the tension between autonomy and more stringent instruments.

1. Introduction

In the Netherlands, residential buildings are responsible for about 9% of CO_2 emissions (Schoots et al., 2016) ,[1] the main greenhouse gas causing climate change. The Dutch Government has a long history in encouraging energy conservation in the built environment. Today, this policy is also propelled by European regulation, in particular by the Energy Performance of Buildings Directive (EPBD). Energy conservation is predominantly driven by the benefits to stakeholders. These benefits include having control over heating costs, a comfortable and healthy indoor environment and an increase in property value (e.g. see Brounen and Kok, 2011; Hu et al., 2014; Ryan and Campbell, 2012). Saving energy is not easy, however, even when the benefits outweigh the investment costs. The Dutch Ministry of the Interior and Kingdom Relations (BZK, 2011) stimulates energy saving behaviour in the built environment. Apart from reducing CO_2 emissions, this policy is also driven by the aspiration to control energy costs for end-users and to stimulate the Dutch construction and installation sector.

Energy saving behaviour in the built environment concerns two types of conduct: 'daily' heating behaviour and the investment decisions that affect the energy performance of buildings (Mills and Schleich, 2012). Daily heating behaviour is recognised as an important factor by scientists (Gram-Hanssen, 2011; Greening et al., 2000; Guerra Santin et al., 2009; Guerra Santin and Itard, 2010) and the Ministry (BZK, 2011; Tigchelaar and Leidelmeijer, 2013). However, most policy instruments in the Netherlands are intended to influence investment decisions and persuade owners to invest in the energy performance of their homes (BZK, 2011; Murphy and Meijer, 2011; Murphy et al., 2012; Noailly and Batrakova, 2010; Vringer et al., 2016).

In 2013, PBL Netherlands Environmental Assessment Agency was asked to assess the national Energy Saving policy for the Built Environment (Vringer et al., 2014, 2016). This assessment was conducted to establish how governments can stimulate investments in the energy performance of the built environment more effectively and efficiently. The assessment was partly based on a decision model for the required investments and a survey among owner-occupiers and tenants. In this article, we aim to contribute to the understanding of the factors that influence the decision to improve the energy performance of existing homes by reporting on the approach, the results and the related policy recommendations. Several models reported in the literature search for relationships between socio-economic household characteristics, attitudes, knowledge, building characteristics and the

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[1] According to this source, national CO_2 emissions totaled 187 Mt CO_2 eq in 2014 (not adjusted for temperature), where 17 Mt CO_2 eq (temperature adjusted) is attributed to residential buildings.

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adoption of measures to improve the energy performance (e.g. see Ameli and Brandt, 2015; Mills and Schleich, 2012). Our analyses and model also try to address the questions of how policy influences investment decisions. To our knowledge, only Murphy (2012) has made a somewhat similar attempt to understand the impact of policy instruments. In addition to Murphy, this article also explores the support for policy instruments.

The Section 2 of this article introduces the model. Section 3 discusses data and methods, followed by the dependent and independent variables in Section 4. Section 5 discusses multiple regression results, where the effects of policy instruments have been controlled for other variables influencing the decision to adopt measures. Finally, in Section 6, policy implications are elaborated.

2. A decision model for energy saving behaviour

We arrived at a relatively simple model for the decision-making process, including the effects of policy instruments. The latter is relatively new to (quantitative) studies on investment decision with regard to the energy performance of dwellings. Our model bears resemblance to the qualitative model developed by the Council for the Environment and Infrastructure (Rli, 2014). This section introduces the model theoretically, supported by references to relevant literature.

In our model (Fig. 1), the physical context shapes the environment within which households decide whether or not to improve the energy performance of their homes. It includes the dwelling itself, household characteristics (including financial possibilities) and housing tenure (Murphy, 2012; Tigchelaar and Leidelmeijer, 2013). Within the physical context, housing tenure is important as this determines who is in charge of the property: owner-occupiers have legal control over their home, while tenants depend on their landlords for substantial investments. Split incentives are common barriers between building owners and tenants (Ameli and Brandt, 2015; Economidou, 2014).

Second, people can be strongly influenced by 'social standards' and the actions of other people (BIT, 2011; Bouma and Dietz, 2013). The influence of social peers refers to the opinions and behaviour of family, friends and enterprises that are important to (potential) investors.

Third, we acknowledge that decisions are taken with a bounded rationality because people do not have unlimited amounts of time, skills or information. Besides the bounded rationality also behavioural processes as described by behavioural economists play a role (see e.g. DellaVigna, 2009; Kahneman, 2011; Thaler and Sunstein, 2008). This is also the case for energy behaviour which leads to the so-called 'energy efficiency gap', caused by not taking profitable investments in energy efficiency (Gillingham and Palmer, 2014; Allcott and Greenstone, 2012). People do less than they would like, are afraid of loss, reluctant out of fear of the hassle involved in renovation, or they underestimate the future financial benefits of energy saving measures. Although understanding of the relevant processes is growing, behavioural processes are complex and very difficult to predict or measure (Frederiks et al., 2015; Antonides and Handgraaf, 2013).

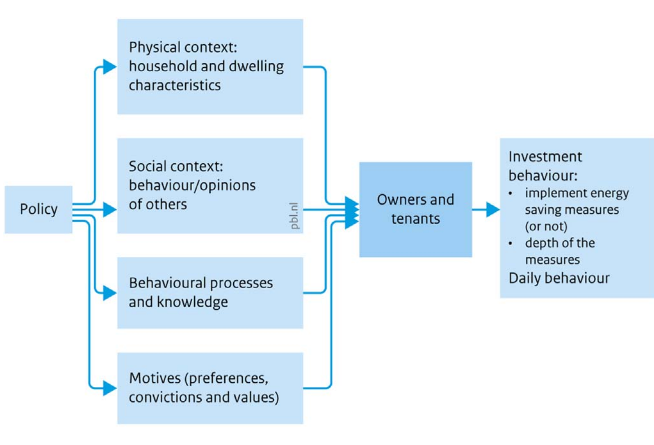

Fig. 1. Behavioural model for tenants and owners.

Fourth, owners and tenants have several motives for taking measures that may influence their decision making. Mills and Schleich (2012) found younger and higher educated households more likely to adopt energy-efficient technologies and energy conservation practices based on environmental motives, while elderly households or households with lower educated members appeared to place more importance on financial savings. Motives can also include other issues, such as comfort, financial considerations, safety and the environment.

Finally, the influence of policy instruments is included. As in most neighbouring countries (OECD, 2007), also in the Netherlands, the government applies a mix of policy instruments, described in the Plan of Action for Energy Saving in the Built Environment (BZK, 2011). Direct policy instruments include subsidies and tax reductions to lower investment costs, energy taxes to reduce the recovery time of investments, cheap loans for financing investments, tailor-made energy advice, Energy Performance Certificates (EPC-labels), and smart meters to stimulate awareness. In the Netherlands, there are no direct legal obligations for existing homes to take certain measures.

Indirect policy instruments are aimed at other, mediating parties. Examples for the Netherlands comprise innovation and stimulation programmes to improve the number of investment options available (from both technological and process-related perspectives; Van Renssen, 2014), higher standards for the energy performance of new buildings, covenants and the adjustment to the Dutch property valuation system (WWS) for the rental sector to allow landlords to recover investment costs by raising the rent.

3. Data and methods

To better understand the decision-making process described in Section 2, we conducted a survey amongst tenants, and homeowners.

3.1. Representativeness and preparation of the survey data

Respondents to the '2012 WoON Energy Module' of the triennial Dutch Housing Survey – a dataset representative of private households in the Netherlands (Tigchelaar and Leidelmeijer, 2013) – were approached a second time. Using the same respondents allowed us to reduce the number of questions and provided very detailed information on households and their homes, including, the EPC-label and recent investments.

In January 2014, the questionnaire was send to 4733 of the original 4790 respondents ,[2] either online or by post. The response amounted to 53% percent, or 2522 respondents .[3] There was no difference between the online and written response rate (Veldkamp, 2014). However, data was lacking from the paper versions as respondents were able to skip questions, either intentionally or by accident. Eighty-six respondents were excluded from the analysis because they had moved house between 2012 and the re-approach in 2014. Another 89 were excluded as they already had implemented all 9 examined measures (see Section 4.1). Finally, respondents with 16 or more

[2] No address information was available for the remaining 57 respondents

[3] These figures relate to the unweighted number of respondents. When using the 2012 WoON Energy Module weight variable to reweight the sample to the Dutch population of private households (i.e. excluding people living in institutions, housing units, houseboats, etc.), the response was just under half the (weighted) population: 3.5 of 7.1 million households. This implies that, on average, respondents that represent household types that were underrepresented in the original sample again were underrepresented in the response. In the remainder of this article, the terms 'respondents' and 'households' will be used interchangeably as the (reweighted) respondent analyses represent households.

unanswered questions were also excluded .[4] This resulted in an unweighted sample of 2267 respondents (see Table 1).

The data were coupled with the 2012 WoON Energy survey data, allowing for a detailed analysis of the response. The weight variable of the 2012 WoON Energy sample was used to get a representative sample of all private households in the Netherlands. The response of the re-approach showed a slight overrepresentation of households in larger family homes, owner-occupied homes outside the larger cities, and households that were intending to improve the energy performance of their house within the next two years. In addition, there was a slightly larger overrepresentation of older, retired couples without children. Finally, households that had already installed PV solar panels in 2012 and claimed to be familiar with their own energy consumption were also overrepresented in the new sample. This last overrepresentation has also been reported by Murphy (2012).

We decided to use the 2012 WoON Energy sample weight variable for the analyses. As a result, we probably overestimated the number of measures to improve the energy performance. The weight factor was not used in the regression analyses as the variables that constitute the weight variable are represented in the context variables.

3.2. Analyses

We examined the behavioural model (Fig. 1) in two steps. First, the relationship (if any) between each couple of dependent and independent variables was established. Second, multiple and logistic regression was used to explore the relationship between each dependent variable and multiple independent variables. As the decision-making processes of owner-occupiers and tenants (and their landlords) are very different, they were analysed separately. Depending on the variable types under consideration, Pearson Chi-square tests, ANOVA F-tests or Pearson correlation coefficients were used to examine the bivariate relationships between dependent and independent variables. Post hoc tests were examined in the ANOVA-analysis (using the conservative Bonferroni Test) to determine differences between groups. Test values are not reported here for reasons of readability. We refer to Vringer, Appendix 2 (in Dutch) et al. (2014)), for a full account of the test values.

3.3. Regression models

Given the decision model (Section 2) and the data (Section 3.1), a multiple regression model can be specified as follows

$$y_j = a + \sum_{\substack{\text{physical} \\ \text{context}}} b_i v_{i,j} + \sum_{\substack{\text{social} \\ \text{context}}} c_i w_{i,j} + \sum_{\substack{\text{behavioural} \\ \text{processes}}} d_i x_{i,j} + \sum_{\text{motives}} e_i y_{i,j} + \sum_{\substack{\text{policy} \\ \text{context}}} f_i z_{i,j} + \varepsilon_j \tag{1}$$

where:

y_j is the share of the potential to improve the energy performance that was implemented between 2010 and 2014 (see Section 4.1); index j denotes the household number (j=1, ..., n)
a is the intercept, to be estimated
$v_{i,j}$, $w_{i,j}$, $x_{i,j}$, $y_{i,j}$ *and* $z_{i,j}$ are the independent variables for the physical and social context, behavioural processes, motives and policy instruments, respectively (see Section 4.2); running index i stands for the explanatory variables involved in each block, and index j for the household number
b_i, c_i, d_i, e_i *and* f_i are the parameters to be estimated for the independent variables
ε_j is the noise series

Here, the dependent y_j is continuous and the model is denoted as a multiple regression model. A similar model can be formulated for the situation where y_j is binary. In that case, model (1) transforms to a logistic regression model.

4. Exploring the model: dependent and independent variables

This section presents and explores the variables that were used. Bivariate analyses are used to explore the relationships between the dependent variables (Section 4.1) and a range of independent variables (Section 4.2).

4.1. Dependent variables

The first step in the (retrospective) investment decision was defined as a dichotomous variable indicating whether or not the *energy performance of a building was improved* between 2010 and 2014. An improvement was defined as one or more measures having been implemented between 2010 and January 2014. The list of measures considered is presented in Table 2.

For households that have taken at least one measure, the *magnitude of the energy performance improvement between 2010 and 2014* was examined by estimating the amount of primary energy (MJ) saved and relating this to the potential to improve the energy performance in 2010. Table 2 displays the weight of each measure. Although the weights are but a rough estimate, they do reflect the fact that, for instance, cavity wall insulation is more effective than draught excluders in saving energy; and a high condensation boiler saves more energy in a large detached house than in an apartment. For example, let us consider a terraced house which, in 2010, had the potential to install floor insulation, PV solar panels, a solar boiler and (partially) insulated glazing. In this case, the 'potential to improve the energy performance in 2010′ amounts to: 7,877+7,826+3,938+(0.5*9,846) = 24,564 MJ. If, in 2012, PV solar panels were installed, the improvement in energy performance amounts to: 7,826/24,564, or 32% of the potential in 2010.

The data show that, on average, 3.9 out of the 9 measures could have been applied to improve the 2010 energy performance of residential buildings in the Netherlands .[5] There are no significant differences between the three housing tenures (owner-occupiers, social rent, private rent).

In 47% of the homes, one or more measures were implemented between 2010 and 2014. We estimated that 18% of the potential to improve the energy performance was implemented. About 52% of owner-occupiers implemented one or more measures, thus realising 21% of the potential improvement in energy performance. In the rental sector, these shares were significantly lower: 38% of buildings owned by social housing associations were improved and 15% of the potential was achieved (including measures implemented by both tenants and landlords). In the private housing sector, the respective shares were 31% and 8%. Installing or renewing high efficiency condensation boilers, efficient shower heads and double glazing are among the most popular measures. The solar boilers is the least popular measure between 2010 and 2014. For cavity wall, roof and floor insulation, PV solar panels and high efficiency condensation boilers Chi-squared analyses indicated significant differences between owner-occupiers, tenants of housing assassinations and tenants of private landlords, where owner-occupants implemented more measures than tenants (and their landlords).

[4] Missing values of respondents with 15 or less missing values were imputed using the average of the other responses.

[5] Note that this average does not include dwellings where all nine measures had already been implemented.

Table 1
Some sample characteristics.

	Owner-occupiers	Tenants (social housing association)	Tenants (private/commercial landlord)	Total
N unweighted (%)	1463 (64.5%)	653 (28.8%)	151 (6.7%)	2267 (100%)
Weighted results				
N (%)	1503 (66.9%)	572 (25.5%)	172 (7.0%)	2267 (100%)
Age (mean/median)	54 / 54 years	57 / 58 years	55 / 56 years	55 / 55 years
Disposable income (mean/median)	€ 43,375 / 39,304	€ 23,531 / 21,079	€ 30,934 / 27,704	€ 37,371 / 32,860
Native Dutch (%)	89%	82%	80%	86%
Single (%)	24%	50%	42%	32%
Couple without children (5)	39%	29%	39%	37%
Couple with children (%)	33%	10%	12%	26%
Apartment (%)	15%	50%	54%	27%
Living space (mean/median)	139/125 m^2	81/75 m^2	105/90 m^2	122 / 110 m^2
Number of measures possible in 2010 (0.5–9)	3.9	3.8	4.0	3.9

Table 2
Weight of energy-saving measures, dependent on dwelling typeSource: Milieucentraal (2014), adaptation by PBL.

		Terraced	Terraced-corner/ semi-detached	Detached	Apartment
1	Roof insulation	12308	14769	24615	14769
2	Solar boiler	3938	3938	3938	2462
3	PV solar panels	7826	12522	23478	7826
4	High efficiency condensation boiler	7532	8862	11963	5317
5	Cavity wall insulation	10338	27077	39385	9354
6	H++glass	9846	11028	14572	7089
7	Floor insulation	7877	9354	16246	12308
8	Water-saving shower head	2095	2356	2356	1396
9	Tube insulation, draught excluders or insulating foil	1745	1964	1964	1164

4.2. Independent variables

4.2.1. Physical context: building and household characteristics

The following building characteristics were examined: housing tenure, dwelling type, living space, property value (approximated as the 'WOZ'-value used in the tax system), construction period, and the number of measures that could have been taken in 2010.

Most of the relations we found between building characteristics and the two independent variables were in line with the literature (see, for example, Ameli and Brandt, 2015; Murphy, 2012; Tigchelaar and Leidelmeijer, 2013). In short, between 2010 and 2014, measures to improve the energy performance were more likely to be implemented in larger, older and more valuable building types and dwellings where many measures were possible. In addition, ANOVA F-tests indicated that the realised potential to improve the energy performance would increase as dwellings were older and more measures were possible. These related relationships were found to be rather strong and can be understood by the fact that more recently constructed buildings often only had a limited potential to further improve their energy performance (i.e. small number of measures). The likelihood of one of those remaining measures having been implemented was small, but if they were implemented, this did achieve a significant share of the potential.

By and large, the relationships in our data between household characteristics and the implementation of (more) measures to improve the energy performance are also in line with the literature (*ibid*). We found that single-person, older, retired, non-western immigrants and lower income households and households with a long duration of residential occupation tended to implement measures less often and/or with lower intensity. In addition, we found a very weak but positive relationship between the annual energy costs and the probability of measures being implemented and the potential to improve the energy performance that would subsequently be achieved. The energy quote, i.e. the disposable income share spent on (residential) energy, and people's intention to move house within the next 5 years hardly had any relation with the decision to implement measures. The last result was not in line with what could be expected on the basis of only financial considerations.

4.2.2. Social context

The influence of social context was measured using 3 pairs of theses and antitheses. We asked respondents to indicate their position on a 5-point scale between these pairs. Responses were converted into a scale ranging from '−2' to '2', where '0' denotes a neutral position between the two theses. Table 3 displays the mean scores for owner-occupiers and tenants who did or did not implement measures between 2010 and 2014. The thesis corresponding to '2' is presented in the first column. Hence, negative values indicate a tendency towards the opposing thesis.

Evidently, our assessment was not exhaustive, but it did provide an indication of the effects of the social environment on the investment decision. ANOVA F-tests indicated significant differences between the four groups, for each pair of theses. These results point towards an interesting contradiction. On the one hand, we found that both owner-occupiers and tenants talk about saving energy and see other people in their vicinity implementing measures. On the other hand, they refute the suggestion that other people have pointed them towards implementing such measures. In another part of the questionnaire, respon-

Table 3
Mean score with 1 Std. error between brackets for three social environment indicators (scale from '−2' to '2'), according to tenure and no or at least one energy-saving measure having been implemented between 2010 and 2014.
Source: Veldkamp (2014), adaptation by PBL

	Owner-occupiers		Tenants	
	Measure (N=775)	No measure (N=728)	Measure (N=273)	No measure (N=471)
Many people in my environment have implemented energy-saving measures	0.37 (0.03)	0.24 (0.04)	0.34 (0.06)	0.04 (0.05)
Others have drawn my attention to energy-saving measures	−0.49 (0.04)	−0.62 (0.04)	−0.37 (0.07)	−0.54 (0.05)
Many people in society talk about energy saving	0.68 (0.03)	0.70 (0.04)	0.86 (0.06)	0.62 (0.05)

dents who had implemented one or more measures were asked to indicate who or what (top 3) had inspired them to do so. No less than 91% of owner-occupiers claimed to have acted of their own accord, only followed by 17% who also did so because of 'the availability of subsidies' and 14% 'because others had also done so'. More strikingly, 73% of tenants also claimed to have acted on their own main accord, followed by 18% who pointed to their landlord, and 14% to 'relatives, neighbours and friends'. Apparently, tenants had the idea that they were in control of their homes, even thought they would depend on their landlord for the majority of possible measures to improve the energy performance of their homes.

4.2.3. Behavioural processes and knowledge

Ramos et al. (2015) report positive relationships between people's educational level and the implementation of energy measures. Murphy (2012), on the other hand, has not found significant effects. In our data, chi-square analysis indicated the level of education to be related positively to implementing measures. However, an ANOVA F-test on the relationship between education and the potential to improve the energy performance did not yield any significant relationships. Households that claim to be aware of their own energy consumption, were found to have implemented measures slightly more often (48% versus an average of 44%) and utilised the potential to improve the energy performance slightly more than other households (41% versus 37%); these differences are significant.

Using a limited number of theses (Table 4; the thesis corresponding to the value '2' is presented in the first column), we explored the influence of behavioural processes. According to Mills and Schleich (2012), knowledge of energy consumption and energy-efficient technology options is related to household energy conservation practices, but not to the adoption of energy-efficient technologies. In our data, however, being well-informed about measures is a distinguishing characteristic of respondents who had implemented such measures. Also, the differences between owner-occupiers and tenants are significant, where homeowners claimed to be more familiar with measures than tenants. A similar pattern was found with regard to competence, i.e. the confidence that one will be able to find the required information on energy-saving measures. The expectation that energy prices would follow an upward trend did not contribute significantly to the implementation of measures. The 'hassle factor', however, was found to be significant. Although, on average, all four groups leaned more towards the thesis 'The hassle around these measures does not discourage me', worries about the stress involved significantly lowered the probability of measures being implemented.

4.2.4. Motives

We measured the influence of motivation for implementing measures using 11 pairs of theses (Table 5).

ANOVA F-tests showed the four groups had at least marginally ($p < 0.10$) significant, different scores on all motives. These differences were caused mainly by differences between owner-occupiers and tenants. For each housing tenure, the environment, comfort level and technical gadgets were found to have appealed similarly to those who had implemented measures and those who had not. Similarly, the desire to heat more rooms against the same costs, the height of investment costs and priding oneself on having implemented measures did not separate the 'investors' from the 'idlers'.

Among owner-occupiers, those who had implemented measures were found to attach significantly more value to lowering energy costs than those who had not. Likewise, those who had implemented measures, more often thought that these measures would contribute to their general health or give them 'a good feeling'. Among tenants, only this last motive showed significant differences between those whose dwellings' energy performance had improved between 2010 and 2014 (thanks to either the tenant or the landlord) and those whose homes had remained unaltered.

The contrasts between owner-occupiers and tenants are more colourful. Owner-occupiers indicated to believe their homes to be significantly better insulated. This group was not as convinced that measures would contribute to their general health. Also, owner-occupiers claimed to lean less towards priding themselves on having implemented measures, or to wanting to heat more rooms against the same costs. Finally, tenants were found to attach slightly more value to a fast recovery of their investment (or probably to the rent increase caused by the improvement in energy performance).

4.2.5. Policy instruments

Several policy instruments were in place between 2010 and 2014. First, we tested the familiarity with instruments (Fig. 2). Even though the responses were informative about the general awareness of policy instruments, they should be regarded with some reservation, as even a fake instrument (a lower property value for tax arrangements for houses with a high energy performance) was 'recognised' by over one in five respondents. Also, tenants were found to be less familiar with the arrangement that the EPC-label, in part, determines the rent level, compared to owner-occupiers, who would not even be affected by this arrangement.

On average, households claimed to be familiar with 6 of 11 instruments (excluding the fake one). ANOVA F-tests showed households that had implemented measures between 2010 and 2014 to recognise significantly more instruments than those who had not. The best known instrument is the subsidy on PV solar panels. Almost 80% of all households was familiar with it, even though this was a relatively small (about 51 million euros) and short-lived (2012–2013) arrangement. In contrast, only 55% of households was familiar with the general energy tax paid by all households and yielding almost 4 billion euros in 2012 (CBS et al., 2014). A mere 30% was aware of the fact that they were actually subject to this tax. This indicates energy taxes, which seriously reduce the time it would take to recover an investment, to do their job almost undetected. It may in part explain why Murphy (2012) has found that only 2,5% of the residents believe that their energy use is influenced by energy taxes.

ANOVA F-tests and Chi-squared tests showed owner-occupiers that had received some form of energy subsidy in the 5 years prior to the

Table 4
Mean score (1 Std. error) for behavioural process indicators (scale from '−2' to '2'), according to tenure and no or at least one energy-saving measure having been implemented between 2010 and 2014.
Source: Veldkamp (2014), adaptation by PBL

	Owner-occupiers		Tenants	
	Measure (N=775)	No measure (N=728)	Measure (N=273)	No measure (N=471)
The hassle around energy-saving measures prevents me from implementing them	−0.77 (0.03)	−0.55 (0.04)	−0.78 (0.06)	−0. 50 (0.05)
I am well-informed about energy-saving measures	0.96 (0.03)	0.79 (0.04)	0.69 (0.06)	0.38 (0.05)
I believe that energy prices will go up in the years to come	1.02 (0.04)	0.95 (0.04)	1.00 (0.06)	0.89 (0.05)
If necessary, I know where to find information on energy-saving measures	1.20 (0.03)	0.96 (0.04)	0.95 (0.06)	0.67 (0.05)

Table 5
Mean score (1 Std. error) on 11 motive indicators (scale from '−2' to '2'), according to tenure and no or at least one energy-saving measure having been implemented between 2010 and 2014.
Source: Veldkamp (2014), adaptation by PBL

	Owner-occupiers		Tenants	
	Measure (N=775)	No measure (N=728)	Measure (N=273)	No measure (N=471)
Energy-saving measures allow me to heat more rooms at little extra costs	−0.54 (0.04)	−0.61 (0.05)	−0.41 (0.08)	−0.18 (0.06)
I want to show that I have implemented measures to save energy	−0.48 (0.05)	−0.49 (0.05)	−0.15 (0.09)	−0.22 (0.06)
The costs of energy-saving measures are too high	−0.26 (0.04)	−0.12 (0.04)	−0.35 (0.07)	−0.19 (0.06)
Energy-saving measures will benefit my health	−0.26 (0.05)	−0.39 (0.05)	0.07 (0.08)	0.05 (0.06)
The time to recover the investment costs is very important to me	−0.14 (0.04)	−0.00 (0.05)	−0.00 (0.07)	0.07 (0.06)
I am very excited about technical gadgets to save energy	0.22 (0.05)	0.15 (0.05)	0.34 (0.08)	0.28 (0.06)
My home is well-insulated	0.66 (0.04)	0.73 (0.04)	−0.07 (0.09)	−0.14 (0.06)
Energy-saving measures make my home more comfortable	0.68 (0.04)	0.31 (0.05)	0.49 (0.07)	0.39 (0.05)
The environment plays an important part in deciding to implement energy saving measures	0.88 (0.04)	0.800 (0.04)	1.02 (0.07)	0.84 (0.05)
Energy-saving measures make me feel good	1.12 (0.03)	0.95 (0.03)	1.18 (0.06)	0.95 (0.05)
I think it is important to lower my energy costs	1.23 (0.03)	1.05 (0.04)	1.29 (0.06)	1.20 (0.05)

2012 WoON Energy survey had implemented measures more often and more extensively between 2010 and 2014 than other households .[6] This is in line with Murphy (2012) who found that 50% of the residents stated that financial instruments were an influence on their energy use. The availability of a tailor-made energy advice, on the other hand, only raised the probability of one or more measures having been implemented, but did not significantly increase the realised potential.

Respondents were asked whether they could remember having received proposals for improving the energy performance of their homes from any of seven types of organisations. On average, households recalled receiving 0.8 offers, in particular from energy companies (37%) and municipalities (10%). Tenants also mentioned their landlord in this respect; 9% in cases where no measures had subsequently been implemented and 16% in cases where one or more measures had been implemented. Owner-occupiers who had implemented one or more measures recalled having received more proposals than other owner-occupiers (1.0 against 0.8); similarly, tenants whose homes had been improved also recalled more proposals than other tenants (0.6 against 0.4).

The EPC-label (ranging from G (poor) to A++(very good)) of each house was established as part of the 2012 WoON Energy survey. During the 2014 re-approach, respondents were asked to estimate the EPC-label of their homes, without informing them about the 2012 results. Even though the questionnaire strongly tried to persuade respondents to provide such an estimation, 53% of households responded 'do not know'. Fig. 3 shows that this share was higher among households that had not implemented any measures between 2010 and 2011 .[7] ANOVA F-tests and post hoc tests showed in particular that "do not know"-households had implemented measures less often between 2010 and 2104. Surprisingly, this also included the tenants, while rent levels are partly based on the EPC-label and most rental homes in the Netherlands are labelled.

The questionnaire also inquired after the possible source of the respondents' EPC estimation; 8% indicated that their homes had an official EPC-label, 4% based their evaluation on an internet website, and the remaining 35% made an unassisted estimation. Chi-squared analysis showed the four groups differed significantly when it came to the implementation of one or more energy-saving measures (between 2010 and 2014). Post hoc analyses demonstrated this to be the result of the 'do not know' households lagging behind the other three groups.

Finally, the questionnaire probed respondents' attitudes towards four existing or possible lines of policy. In this case, they were presented with four theses (without anti-theses). Responses ranged from 'strongly disagree' ('−2') to 'strongly agree' ('2'). Fig. 4 shows a solid support for the existing regulations for new buildings and government 'assistance' to save energy. However, the existing, obligatory EPC-label was not very popular among owner-occupiers, whereas tenants were moderately positive. Strikingly, owner-occupiers indicated they would be moderately supportive of currently non-existent regulations for existing buildings, with half of them (strongly) agreeing with the thesis 'The government is allowed to set energy performance standards for existing buildings'. Tenants were even more supportive of this possible new line of policy, with 70% indicating they would be in favour. ANOVA F-tests and post hoc tests showed no significant differences between households within each segment.

5. Statistical results

This section describes and discusses four regression models that might explain energy performance improvements in existing houses.

5.1. Regression models

The independent variables described in Section 4.2 were used in four regression models. Two logistic regression models, one for tenants (N=804) and one for owner-occupiers (N=1463), were estimated to explain people's *decision to implement measures* to improve the energy performance of their homes *between 2010 and 2014* (or, to be precise: the odds of the decision to have implemented one or more measures between 2010 and 2014 and of not having done so). Similarly, two multiple regression models were estimated to explain *the magnitude (%) of the energy performance improvement that was realised when one or more measures had been implemented between 2010 and 2014* (cf. Eq. (1)). Thus, these latter models are estimated on subsets of the first sets of data (a subset of 35% for tenants and 50% for owner-occupiers). This data restriction for the multiple regression models avoids problems with non-normal distributions of the responses due to a high number of respondents with zero implemented improvement measures. SPSS was used to estimate the models. We note that our purpose here is *not* to predict the number of measures taken, including no measure taken at all. In that case a prediction model should be applied which combines a logistic regression model and multiple

[6] This conclusion is mainly relevant with regard to the size of the investment, as households that had received a subsidy obviously were more likely to have implemented one or more measures (even though the periods do not overlap perfectly).

[7] Respondents who had implemented measures in 2012 or beyond, were removed from the analyses in Fig. 3, as these measures may have affected the EPC-label; the share of households that 'did not know' is slightly higher in Fig. 3 (56%) than in the entire sample (53%).

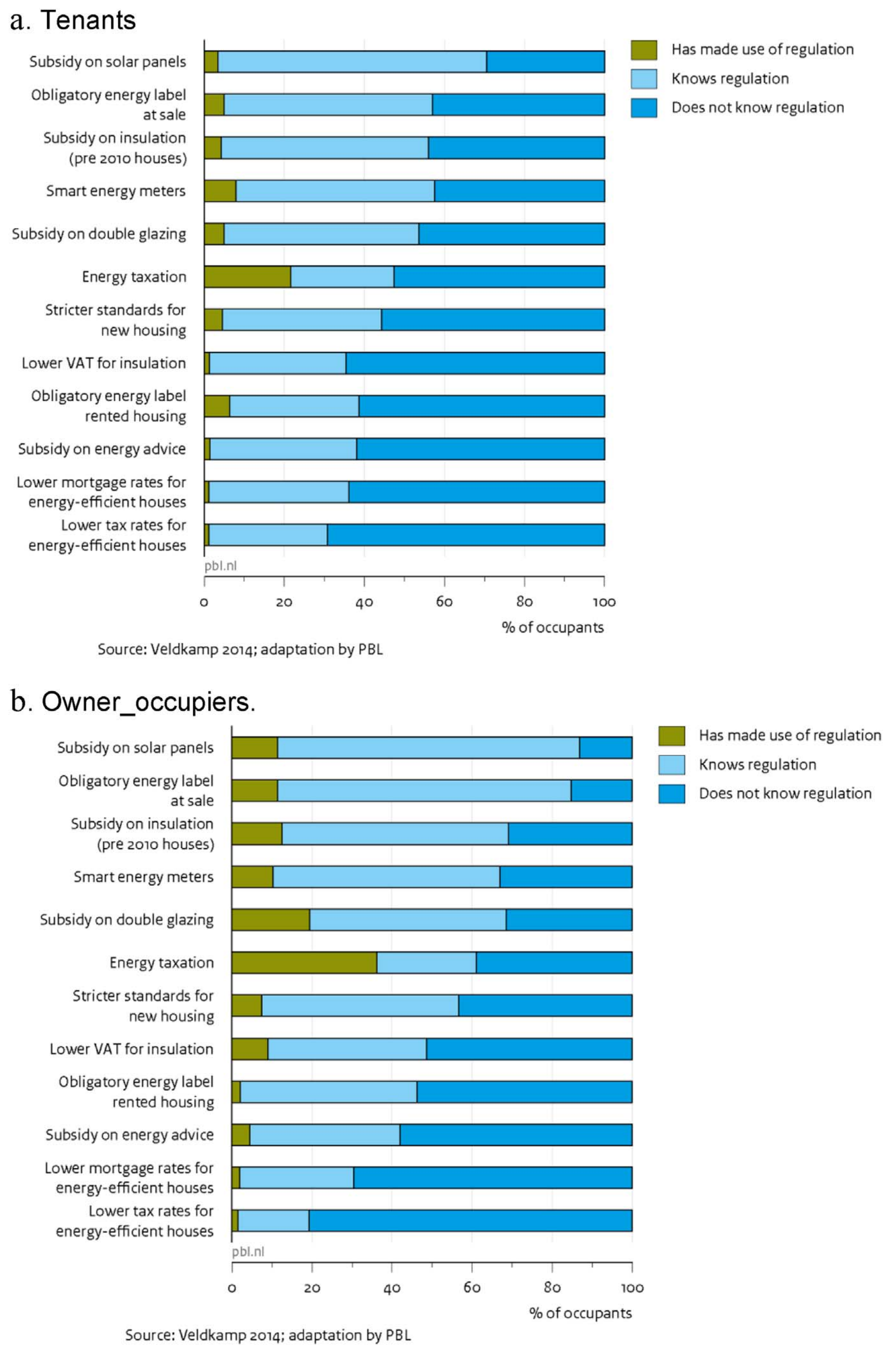

Fig. 2. Use of and/or familiarity with policy instruments among Dutch households; tenants (a) and owner-occupiers (b).

regression model. There are several ways for doing that, we refer to Heckman (1979) or Fletcher et al. (2005). Rather than prediction our aim is to find the variables which influence peoples decisions for energy improvements.

First, the models were estimated using all independent variables. Since the respondents' degree of familiarity with the main policy instruments proved to be highly interdependent, we used the number of instruments that respondents were familiar with (ranging from 0 to 11) instead of their experience with individual instruments, to avoid the effects of multicollinearity. Next, the models were re-estimated, using only those variables with a (marginally) significant effect in at least one of the four models. However, we did not remove policy variables, as these are our main focus. Additionally, we have performed a number of stability tests .[8] Finally, two control variables were tested: (1) online or written response, and (2) the number of imputed variables

[8] We have repeated the regressions without the insignificant variables ($p < 0.10$) to test the stability of the models. These tests show the models to be stable enough; for all four models the B-signs (+/-) were the same as in the reported models and the B-values changed within reasonable limits; two parameters changed to insignificant (p=0.152 and p=0.192) and two parameters changed to nearly marginally significant (p=0.109 and p=0.114); the R^2-values drop only slightly. In addition we checked for high correlations between independent variables to explore the risk of multicollinearity, one of the sources of instability. These results did not lead to adaptations in the final set of variables presented in Tables 6 and 7.

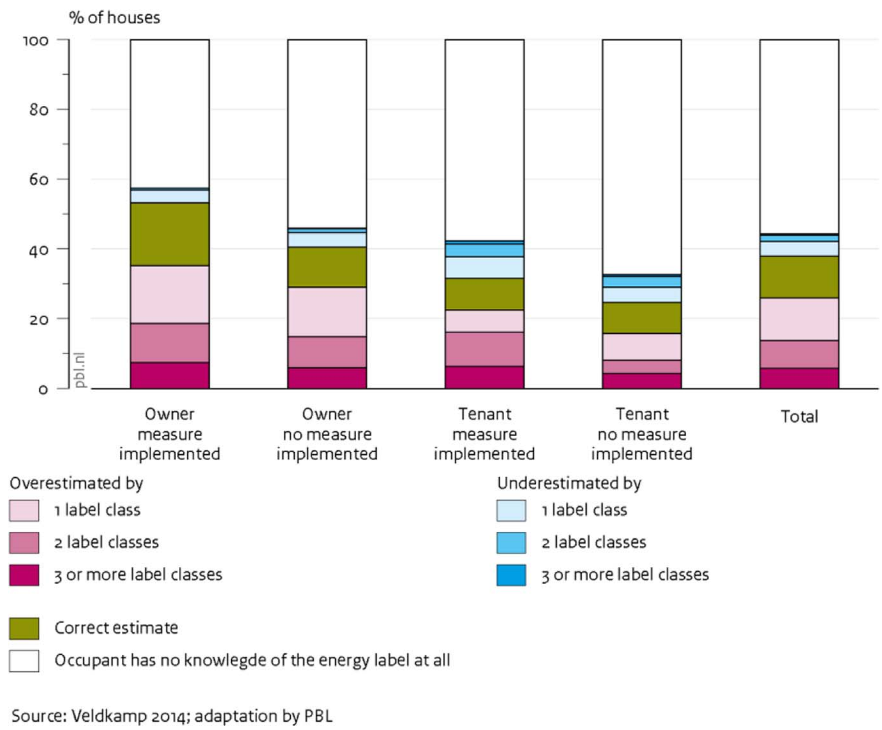

Fig. 3. Overestimations and underestimations of the EPC-label of properties according to tenants and owner-occupiers.

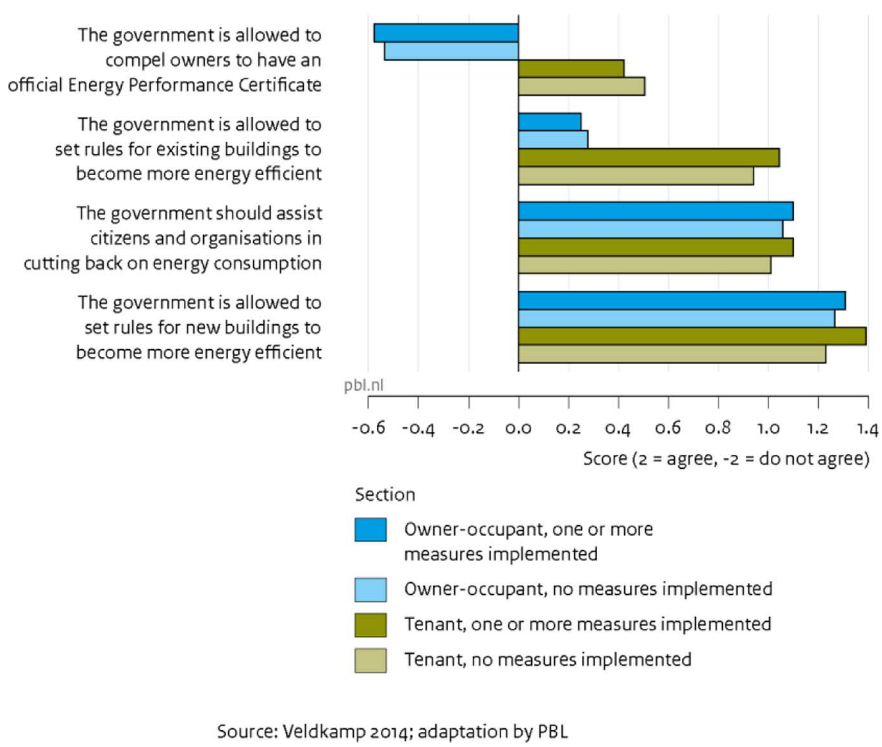

Fig. 4. Mean score on responses to policy options (scale from '−2'/disagree to '2'/agree), according to tenure and no or at least one energy-saving measure having been implemented 2010 and 2014.

(for each respondent) due to missing responses. Both control variables proved to be insignificant and were removed.

Results are presented in Tables 6 and 7. The Chi-square- and F-values show the models to fit the data better than an intercept-only model; the 44 (owner-occupiers) to 45 (tenants) independent variables explain 19–37% of the observed variance. Additional analyses [9] show

[9] The regression models were re-estimated several times using the variables of a single component in de decision making model and the explained variances by each component were compared.

Table 6
Logistic (measures implemented between 2010 and 2014, or not) and multiple regression model (share of realised energy-saving potential) for tenants.

	Logistic model (N=804)			Multiple model (N=283)		
	B	S.E.		B	S.E.	
(Intercept)	−2.441	0.539	***	80.818	10.761	***
Physical context: household and dwelling						
Household composition (ref: single)						
– Couple without children	0.040	0.222		−10.111	4.388	**
– Couple with children	0.175	0.378		−12.049	7.099	*
– Other	0.297	0.344		−12.71	5.939	**
Age (squared) (x 1000)	−0.207	0.089	**	2.364	1.587	
Disposable income (x €10,000)	0.073	0.099		4.241	1.895	**
Main source of income (ref: in employment)						
– Retirement pension	0.485	0.304		−1.321	5.505	
– Entrepreneur/director and major shareholder / own funds	−0.765	0.412	*	−6.967	8.735	
– Other (unemployment or supplementary benefit, student)	0.15	0.288		2.552	5.143	
Ethnicity (ref: native)						
– Non-western immigrant	−0.184	0.495		−2.497	9.33	
– Western immigrant	0.636	0.294	**	−6.577	5.287	
Duration of residential occupation (in years)	−0.009	0.007		−0.226	0.138	
Private/commercial landlord (ref: social housing association)	−0.693	0.257	***	−0.412	4.991	
Dwelling type (ref: terraced)						
– Apartment (multi-family building)	−0.008	0.198		−7.842	4.017	*
– Semi-detached	0.264	0.443		−7.672	8.112	
– Detached	−0.516	0.879		25.849	21.144	
Construction period (ref: prior to 1960)						
– 2000 or later	−0.233	0.432		11.463	8.368	
– 1990 to 1999	0.596	0.333	*	−8.096	6.178	
– 1980 to 1989	−0.583	0.289	**	−15.385	5.721	***
– 1970 to 1979	0.462	0.258	*	−12.198	4.599	***
– 1960 to 1969	0.215	0.272		−12.282	5.279	**
Number of measures possible in 2010 (0–9)	0.385	0.049	***	−3.582	0.909	***
Property value (WOZ; x €100,000)	−0.015	0.141		−8.508	3.436	**
Social context						
Many people in my environment have implemented energy-saving measures	0.231	0.097	**	1.957	1.748	
Others have drawn my attention to energy-saving measures	0.081	0.079		0.564	1.469	
Behavioural processes and knowledge						
I am well-informed about energy-saving measures	0.172	0.092	*	0.274	1.728	
Motives						
The time to recover the investment costs is very important to me	−0.020	0.072		3.046	1.379	**
Energy-saving measures make my home more comfortable	0.053	0.083		1.773	1.528	
Energy-saving measures allow me to heat more rooms at little extra costs	−0.234	0.074	***	−0.409	1.352	
My home is well-insulated	0.100	0.074		5.263	1.359	**
Policy						
Energy certificate (ref: none, but respondent did give his own evaluation)						
– Official Energy Performance Certificate available	0.287	0.358		−3.841	6.269	
– Not available, evaluation based on internet site	−0.366	0.608		−8.762	10.401	
– Not available/ do not know	0.079	0.205		−9.404	3.769	**
The government should assist citizens and organisations	−0.066	0.128		−4.418	2.526	*
The government is allowed to set rules for new buildings	0.255	0.147	*	−6.076	2.892	**
The government is allowed to set rules for existing buildings	0.021	0.135		7.372	2.629	***
The government is allowed to compel owners to have an EPC	−0.085	0.091		−0.484	1.639	
Proposition: familiar construction/installation company	0.586	0.509		−4.685	8.891	
Proposition: previously unknown construction/installation company	−1.008	0.741		−1.14	16.428	
Proposition: energy company	0.062	0.2		−3.817	3.735	
Proposition: local government	−0.376	0.392		−7.817	7.017	
Proposition: landlord	0.339	0.273		8.172	4.616	*
Proposition: owner-occupiers'/residents' association	0.878	0.723		−16.688	11.301	
Tailor-made energy advice (ref: not available)						
– Tailor-made energy advice available	0.370	0.561		18.674	8.685	**
– I do not know what a tailor-made energy advice is	0.008	0.186		0.026	3.594	
Number of policy instruments that the respondent is familiar with (0–11)	0.051	0.025	**	0.132	0.475	

Logistic model: Chi^2=194.806; df=45; p=0.000; Cox & Snell R^2 =0.215; Nagelkerke R^2 =0.296.
Linear model: F=3.086; df =45; p=0.000; R^2 =0.369.

* 0.05≤ p < 0.10.
** 0.01≤ p < 0. 05.
*** p < 0.01.

Table 7
Logistic (measures implemented between 2010 and 2014, or not) and multiple regression model (share of realised energy-saving potential) for owner-occupiers.

	Logistic model (N=1463)			Linear model (N=726)		
	B	S.E.		B	S.E.	
(Intercept)	−1.725	0.402	***	71.187	6.540	***
Physical context: household and dwelling						
Household composition (ref: single)						
– Couple without children	0.374	0.166	**	−1.539	2.751	
– Couple with children	0.272	0.203		−2.346	3.153	
– Other	0.008	0.326		−5.226	5.330	
Age (squared) (x 1000)	−0.081	0.071		−1.183	1.122	
Disposable income (x €10,000)	−0.032	0.032		0.295	0.492	
Main source of income (ref: in employment)						
– Retirement pension	0.048	0.200		0.477	3.241	
– Entrepreneur/director and major shareholder / own funds	0.677	0.202	***	−6.78	2.774	**
– Other (unemployment or supplementary benefit, student)	0.366	0.335		−2.406	5.271	
Ethnicity (ref: native)						
– Non-western immigrant	−0.142	0.603		−2.005	10.401	
– Western immigrant	0.342	0.239		0.263	3.459	
Duration of residential occupation (in years)	−0.015	0.006	**	−0.153	0.101	
Dwelling type (ref: terraced)						
– Apartment (multi-family building)	0.185	0.203		0.355	3.270	
– Semi-detached	0.113	0.164		2.03	2.562	
– Detached	0.244	0.174		8.236	2.762	***
Construction period (ref: prior to 1960)						
– 2000 or later	−1.052	0.258	***	0.361	4.501	
– 1990 to 1999	0.009	0.205		−4.149	3.153	
– 1980 to 1989	−0.411	0.196	**	−0.534	3.244	
– 1970 to 1979	−0.165	0.184		−1.484	2.789	
– 1960 to1969	0.045	0.217		−4.04	3.29	
Number of measures possible in 2010 (0–9)	0.402	0.039	***	−6.067	0.568	***
Property value (WOZ; x €100,000)	−0.019	0.054		−0.711	0.931	
Social context						
Many people in my environment have taken energy-saving measures	−0.055	0.071		−1.367	1.145	
Others have drawn my attention to energy-saving measures	0.105	0.057	*	0.607	0.869	
Behavioural processes and knowledge						
I am well informed about energy saving measures	0.107	0.072		3.606	1.194	***
Motives						
The time to recover the investment costs is very important to me	−0.057	0.049		−0.269	0.803	
Energy saving measures make my home more comfortable	0.142	0.057	**	0.782	0.93	
Energy saving measures allow me to heat more rooms at little extra costs	−0.050	0.052		1.042	0.825	
My home is well insulated	0.178	0.066	***	4.928	1.023	***
Policy						
Energy certificate (ref: none, but respondent did give his own evaluation)						
– Official Energy Performance Certificate available	0.027	0.245		3.186	3.559	
– Not available, evaluation based on internet site	0.367	0.315		5.895	4.287	
– Not available/no clue	−0.225	0.129	*	−1.781	2.087	
The government should assist citizens and organisations	−0.073	0.078		0.035	1.224	
The government is allowed to set rules for new buildings	−0.033	0.084		1.445	1.313	
The government is allowed to set rules for existing buildings	0.041	0.069		−0.010	1.092	
The government is allowed to compel home-owners to have an EPC	−0.079	0.061		0.539	0.973	
Proposition: familiar construction/installation company	0.294	0.159	*	0.739	2.294	
Proposition: previously unknown construction/installation company	0.244	0.194		2.777	2.777	
Proposition: energy company	0.101	0.124		−2.12	1.964	
Proposition: local government	0.222	0.188		−2.116	2.728	
Proposition: owner-occupiers'/residents' association	0.023	0.35		−0.658	5.536	
Respondent received subsidy in 5 years prior to the 2012 WoON Energy survey	0.727	0.249	**	10.522	3.052	***
Tailor made energy advise (ref: not available)						
– Tailor made energy advise available	0.188	0.234		−3.426	3.342	
– I do not know what a tailor made energy advise is	0.176	0.153		−0.976	2.433	
Number of policy instruments that the respondent is familiar with (0–11)	0.048	0.022	**	−0.136	0.364	

Logistic model: Chi^2=315.209; df=44; p=0.000; Cox & Snell R^2 =0.194; Nagelkerke R^2 =0.258; **Linear model**: F=7.538 df=44; p=0.000; R^2=0.328.
* $0.05 \leq p < 0.10$.
** $0.01 \leq p < 0.05$.
*** $p < 0.01$.

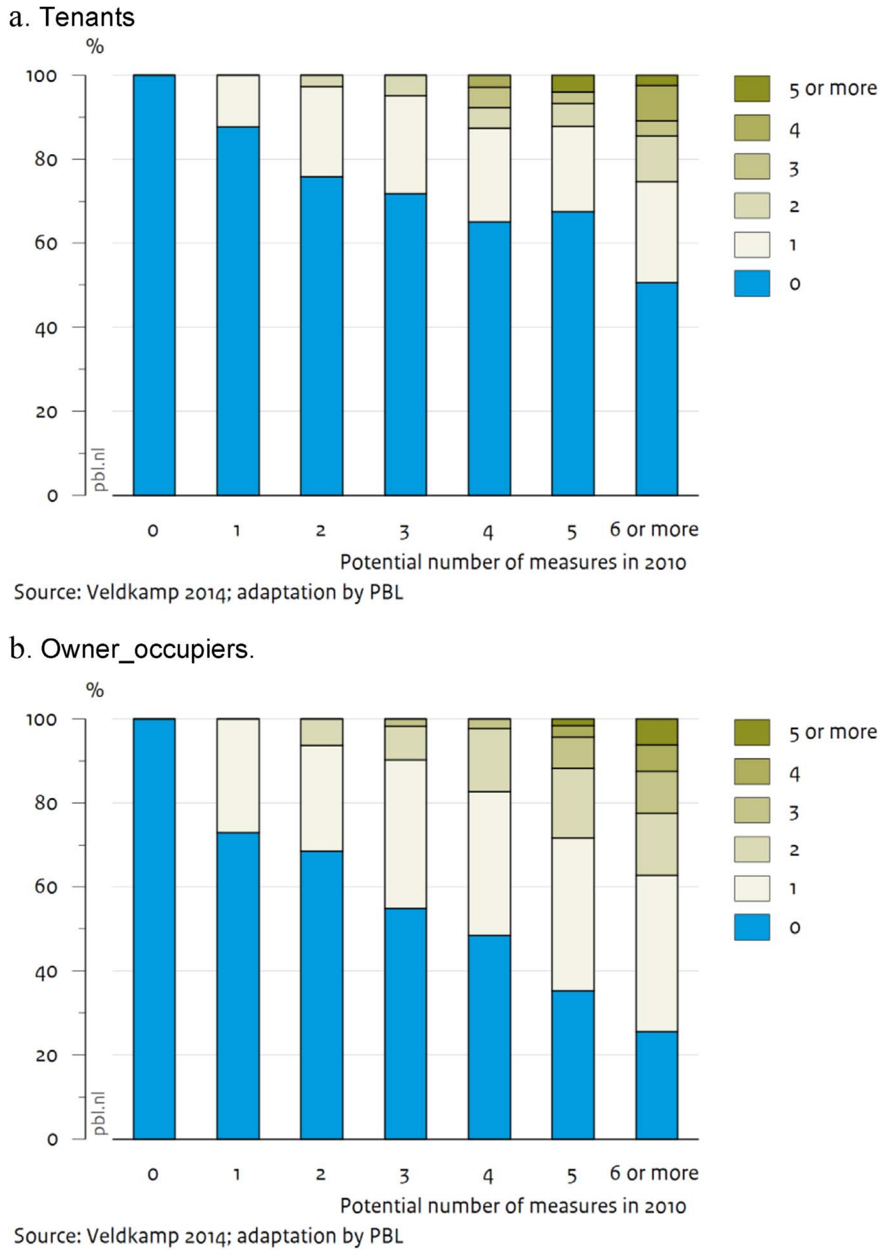

Fig. 5. Percentage of dwellings were 0, 1, 2, 3, 4, or 5 or more substantial energy saving measures have been implemented between 2010 and 2014, depending on the number of possible measures in 2010; tenants (a) and owner-occupiers (b).

that the physical context, and in particular the dwelling characteristics, substantially contribute to explaining the variances in the investment decisions. Dwelling characteristics single-handedly make up for almost two-third of the total explained variance in the decision to implement one or more measures, where policy measures make up for about 20% of the explained variance. Dwelling characteristics also dominate the realised potential to improve the energy performance (70% of the total explained variance for owner occupiers and 40% for tenants), but motives are also important (almost 40% for owner-occupiers and 30% for tenants); note that the totals exceed 100%, indicating some overlap between de components.

By and large, the results support those of the previous analyses. We restrict the discussion to important contradictions and confirmations of the main relationships and observations.

5.2. Results for contexts, motives and behavioural processes

The multiple results confirm the divergent position of the private housing sector, that apparently less often implemented any measures to improve the energy performance of their properties, even when controlled for context variables. Regression models with both tenants and owner-occupiers (not reported here) do not show significant differences between social housing associations and owner-occupiers. Hence, the observed differences reported in Section 4.1 between social housing associations and owner-occupiers may very well be due to variations in building and/or occupant characteristics.

Several household characteristics proved to be relevant. The probability of implementing one or more measures was shown to be higher for only tenants with a western background. Apparently, the negative relationships between a non-western background and implementing measures as observed in the bi-variate analysis can be explained by other factors. Older tenants are less likely to implement measures. Similarly, for owner-occupiers, we found a longer length of residence to be related to a lower likelihood of measures being implemented. For owner-occupiers, the logistic model showed that couples without children would implement measures more often. In contrast, for tenants of properties where measures had been implemented, the model results contradicted the idea of single-person households saving less energy than others. In addition, higher income tenants of properties where one or more measures had been implemented were found to have a higher magnitude of energy performance improvement. Whether this had to do with their acceptance of potential rent increases as a result of these measures cannot be deduced from the models, but does appear a plausible explanation. Some relationships between the income source and measures being implemented were found to be significant, yet also too ambiguous to serve as an explanation.

The multiple regression models indicated that the lagging behind of apartments only applied to the rental sector, whereas for detached houses, more of the potential to improve the energy performance was achieved by owner-occupiers. For tenants, the models furthermore indicated that this realised potential decreased with property value. The number of possible measures implemented in 2010 was found to be the most relevant building characteristic. It is the only variable that is highly significant in all four models. For both rented and owner-occupied houses, the probability of one or more measures having been implemented was found to increase with the potential number of measures that could have been implemented in 2010 (B-values: 0.385 and 0.402 respectively; see Tables 6 and 7), while the realised potential to improve the energy performance decreased by the same variable (B-values: −3.582 and −6.067 respectively). These effects have two important implications. First, since the remaining number of measures to be implemented is controlled for in the models, the construction-period parameter may have varying implications (e.g. the period between 1980 and 1989 has a negative effect). For example, the parameter may be indicative of idiosyncrasies in maintenance cycles, or of a possible lack of suitable market proposals for particular types of buildings from a specific time period. Second, the effect of the number of possible measures in the models indicates the energy performance of houses to be improved one at a time, instead of all at once. This conclusion is also supported by the positive relationships between the two dependent variables and the choice of motive ‘My home is well insulated’ (B-values: 0.100 (not significant) and 5.263 for the rental models and 0.178 and 4.928 for the owner-occupied models) – included in the questionnaire so that respondents could indicate that they did not implement any measures because their homes already had a high energy performance. Together with the number of possible measures, this motive is among the most influential variables. Fig. 5 illustrates this step-by-step process for substantial measures (i.e. excluding water-saving shower heads and tube insulation). It shows that, once households had start implementing certain measures they were likely to continue to do so until eventually all possible measures would be implemented.

In line with the bivariate analysis, the regression results indicated small but significant relationships between the social context and the decision of implementing one or more measures. We also found that being well-informed helped both tenants and owner-occupiers to decide to implement more measures. With regard to people's motives, the models showed that tenants who indicated to attach a great deal of weight to the recovery time had realised more of the potential improvement in energy performance. In addition, for tenants who had indicated not to be inclined to heat more rooms in their homes only because improvement measures would make this cheaper, we found that they more often had implemented such measures between 2010 and 2014. For owner-occupiers, the belief that measures would contribute to the comfort level of their homes increased the likelihood of them having implemented these measures.

5.3. Results for policy instruments

For owner-occupiers, the regression models confirmed that subsidy recipients were not only more likely to have implemented energy improvement measures, but also had realised more of the potential improvement .[10]

As mentioned earlier, we found familiarity with policy arrangements to be related to implementing measures. The regression models confirmed this for both tenants and owner-occupiers. The number of policy instruments respondents said to recognise did not have a significant effect on the realised potential.

For owner-occupiers, a lack of understanding of the EPC-label of their homes was found to coincide with a lower probability of one or more measures having been implemented. For tenants who had implemented one or more measures, this lack of understanding resulted in a smaller part of the energy-saving potential having been achieved. Tenants who had received tailor-made energy advice, on the other hand, had realised a larger part of that potential.

With respect to any offers that respondents indicated to have had about energy-saving measures, owner-occupiers were positively influenced by offers only from construction and installation firms they were familiar with. Tenants proved to be sensitive to offers made by their landlords. The latter may be related to the fact that tenants are able to implement relatively simple measures (e.g. weather strips) themselves, whereas measures that require a more substantial investment, would require the involvement of landlords.

Finally, for owner-occupiers, the models showed that attitudes towards government policies had no distinct impact on whether or not measures had been implemented. For tenants, on the other hand, we found some significant differences. The support for regulations for new buildings (this is existing policy) was found to be positively related to measures having been implemented, but also the realisation of a smaller part of the potential. Tenants who had implemented one or more measures, more often supported government regulations for existing buildings when they had realised a larger part of the potential between 2010 and 2014. It is quite possible that these tenants had positive experiences and believed that those measures should be part of the building standard. Agreeing to the government helping citizens and businesses, on the other hand, was found to be related to a smaller part of the potential having been achieved. Perhaps these were tenants who were disappointed in the actions of their landlords and hoped that the government could help to change this.

6. Conclusions and policy implications

The Dutch Government has been trying to reduce energy consumption in the built environment, since the energy crisis of the 1970s. Over the course of time, a mix of policy instruments has been implemented. For this article, we explored the decision-making process of households for implementing energy saving measures to their homes. In addition to the existing literature we also included information on the knowledge of and support for (existing and possible) policy instruments. Using these insights, in this final section we reflect on the role of several important policy instruments.

Our results can be summarised in four main conclusions and accompanying policy recommendations. First, Sections 4.1 and 5.2 showed relevant differences between the owner-occupied and the rental sector. The private housing sector is lagging behind seriously when it comes to improving the energy performance of their housing stock. This sector is small, about 22% of the entire rental sector, covering less than 10% of the total housing stock in the Netherlands. However, the present government policy, potentially, may boost the

[10] Subsidies were not included in the tenant models as tenants are not entitled to subsidies.

private housing sector in the future. This calls for serious attention for the policy instruments targeted on this sector (covenants, subsidies, property valuation system (WWS)) if the energy performance of the total stock is to improve according to policy targets. In addition, our analyses have pointed to the fact that rental apartments and houses built in the 1980s have lower energy improvements than other building types (Sections 4.2.1 and 5.2). This may point to the importance of regular maintenance or a possible lack of (cost-effective) solutions for these building types.

Second, our results showed that, during the period covered in our study, improvement in the energy performance of Dutch homes was done according to a process of one, or only a few steps at a time. Graphically this is evident from Figs. 5a and b. And Sections 4.2.1 and 5.2 showed the number of measures possible in 2010 to be one of the best predictors of whether or not the energy performance of a building was improved. Though at a very low rate, most of the required measures eventually will be implemented; it will ‘simply’ be a matter of speeding up the process. However, this process is not focused on innovations and, by itself, would arguably not lead to an energy-neutral build environment. The Dutch Government, therefore, is also stimulating a market approach to producing (nearly) zero-energy buildings, both newly built and retrofitted (Van Renssen, 2014)). This combination seems to be a good strategy. The government makes use of the mass movement taking small steps, while also advancing innovations to single–large–step propositions. We do, however, recommend the development of a practice in which knowledge and experience is exchanged between these two policy lines, to learn from each other and to develop a strategy of applying the two policy lines to the whole housing stock towards an energy-neutral built environment in 2050.

Third, our analyses revealed that households expressed a strong desire to be in control of their own homes (Section 4.2.2). Obviously, policy instruments may conflict with this wish or perception to act autonomously. For instance, tenants were found to be sensitive to financial considerations in combination with an obvious lack of interest and/or knowledge with regard to the EPC-label and its role in determining the (maximum) rent level (Sections 4.2.4 and 5.2). At the same time, Section 4.2.5 showed tenants agreed with the policy of setting higher energy performance standards for existing homes. We found that around half of the owner-occupiers also indicated to be open to energy performance standards for existing homes.. A carefully designed policy and communication strategy could bridge this area of tension. In addition, housing associations could try to win over tenants by using a customer-directed approach, providing better information and guarantees that overall housing costs, including rent and energy costs, will remain steady, despite a rent increase related to the implementation of energy-saving measures.

Finally, our results underline the importance of well-informed and competent decision-makers (Sections 4.2.3, 4.2.5 and 5.2). This calls for attention to information instruments. Murphy (2014) found the EPC-label to have a weak influence on the adoption of measures. In contrast, we found that ill-informed households that were not aware of the energy performance of their homes had taken fewer measures. Owner-occupiers and tenants who indicated to have knowledge of their EPC-label did implement or allowed their landlords to implement more measures to improve the energy performance of their homes. This indicates the EPC-label to give (interested) households something to build on, or enable them to efficiently recap the energy performance of their homes. The challenge for the future lies in stimulating the large group of people who are unaware of the energy performance of their homes. However, if the EPC-label is to become more effective, merely issuing such labels will not be enough. This is in line with the recommendation by Murphy (2014) that the EPC should be part of a mix of instruments. It will take a balanced combination of information, interest, and repeated communication. For instance, the EPC-label could become connected to the amount of property or energy tax that people pay. This could also be a first step towards reducing the tension between people's desired autonomy with regard to their homes and more stringent policy instruments for existing homes. Furthermore, communication about the EPC-label should be a repeated process and well-timed intervention; for example, through people's energy bill. Only then, the labels G through A++ can become one of the symbols for housing quality.

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