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Energy Efficiency Standards of Single-Family Houses: Factors in Homeowners' Decision-Making in Two Austrian Regions

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Abstract

The energy efficiency of residential buildings is a central issue in the widely discussed energy transition. This study investigates which factors influence homeowners´ decisions regarding the energy efficiency standard of their houses. Homeowners who built or renovated their houses between 2008 and 2013 participated in a questionnaire survey in two Austrian "energy regions" within the federal states of Styria and Burgenland. In the majority (66%) of cases, homeowners chose the low-energy house standard B (≤ 50kWh/m^{2}a) for their building or renovation projects, followed by the conventional standard C (≤ 100kWh/m^{2}a) (21%). Only 13% realized ultra-low-energy, passive or plus-energy houses with a higher energy efficiency standard (A (≤ 25kWh/m^{2}a), A+ (≤ 15kWh/m^{2}a), or A++ (≤ 10kWh/m^{2}a)). Expert recommendations on energy standards showed the highest correlation with the selected standards, and on average, new building projects realized better energy efficiency standards than did renovations. Further variables that were significantly related to the realized standards included homeowners' attitudes and knowledge about building energy efficiency standards and the age of the respondents. Although the homeowners who were surveyed were initially satisfied with the selected energy efficiency standard, many now indicate a preference to implement significantly higher energy efficiency standards than those achieved in their project. Further, they would recommend even significantly higher energy efficiency standards to friends than the standards preferred for their own house. These findings suggest that current preferences and communication in social networks promote higher future energy efficiency standards.

Keywords: agent-centered framework, decision-making, energy efficiency standards, energy region, energy transition, renovation, residential building, satisfaction, preferences

1. Introduction

A central issue in the widely discussed energy transition is the energy demand of residential buildings, particularly in countries in which space heating is necessary and few energy sources exist. One example is Austria, which imports approximately 65% of its energy (Europe´s Energy Portal, 2013) and where the number of *heating degree days* in the different regions ranges from 3080 to 6365, with the latter defined as the product of the number of days with heating demand (i.e., in Austria, the number of days with an outside temperature < 12°C) multiplied by the average difference between 20°C (agreeable room temperature) and the average outside temperature on these days (Krischan, 2013a,b; Paschotta, 2015).

The potential for savings in Austria's residential construction and renovation sectors is high because heating and hot water account for 87% of the total household energy demand (Bohunovsky, 2008). The European directive 2002/91/CE on the energy performance of buildings, which aims to foster energy efficiency and energy savings in buildings, has been implemented in Austria in the state and provincial (federal states) laws and bylaws. In addition, numerous subsidy schemes for the promotion of energy efficiency in single-family houses at the state, provincial and municipality level provide considerable financial support. Although the market potential of very energy efficient houses, such as passive or plus energy houses, is strong in Austria, the implementation rate remains low because homeowners rarely implement the most energy efficient technologies in building and renovation projects (Plate, Moser, & Elvin, 2010).

Homeowners' decision-making concerning the energy efficiency of their houses is a complex decision situation (Frederiks, Stenner, & Hobman, 2015). Although such decisions occur only once or twice in a lifetime, they have a long-term effect on households' energy consumption. Previous research has suggested that economic aspects, contextual factors, involved actors, and sociological and psychological factors such as awareness, knowledge level, and technology acceptance are influential determinants in private households' decision-making on energy issues (see, e.g., Neij, Mundaca, & Moukhametshina, 2009; Wilson & Dowlatabadi, 2007). Studies have examined the role of these factors on homeowners' willingness to implement energy-saving measures and have made recommendations regarding how to influence energy-related decisions and overcome barriers to implementing corresponding measures (Backhaus, Tigchelaar, & Best-Waldhober, 2011; Banfi, Farsi, Filippini, & Jakob, 2008; Gram-Hanssen, Bartiaux, Jensen, & Cantaert, 2007; Lutzenhiser & Shove, 1999; Rohracher & Ornetzeder, 2002, 2008). Furthermore, scholars have analyzed user acceptance and satisfaction regarding sustainable building technologies (e.g., Rohracher & Ornetzeder, 2002, 2008). Studies also have shown that households' preferences differ from region to region (Backhaus et al., 2011; Plate et al., 2010; Sopha, Klöckner, Skjevrak, & Hertwich, 2010; Nair, Gustavsson, & Mahapatra, 2010a) and that external, contextual factors at the state, regional or even local level constrain the possible decision options.

However, none of these existing studies has quantitatively examined the extent to which different factors, such as knowledge and attitudes toward energy efficiency, technology acceptance, economic aspects, contextual factors and involved actors influence homeowners' decisions on the energy efficiency standards of the building as reflected in energy labels (A^{++}, A^{+}, A, B, and C, as described below) of contemporary energy efficiency schemes. Recent changes in zoning laws, energy efficiency standards, subsidy systems and local activities (e.g., "energy regions") may have triggered specific developments that require an analysis of specific domains. To contribute to knowledge on this issue, we address the following research questions:

1) Which energy efficiency standards do homeowners in two Austrian energy regions choose for the construction or renovation of their single-family houses?
2) When considering energy efficiency standards, what are the main factors that influence homeowners' decision-making during a building or renovation project?
3) How satisfied are homeowners with the energy standard that they selected in their building or renovation project, and how does this influence current preferences and intentions for recommendations of such standards to other persons in their social network?

This paper quantitatively analyzes the building and renovation projects of single-family houses in two regions of Austria. In Section 2, we provide a short introduction to our study regions, the procedure and method of the research and the analytical framework. In Section 3, we present the main results from the survey, and in Section 4, we discuss their implications. Section 5 draws conclusions regarding interventions to promote higher energy efficiency standards and makes suggestions for further research.

2. Materials and Methods

2.1 Study Regions

The study area encompasses two regions in Austria, namely the "Energieregion Weiz-Gleisdorf" in Styria and the "ökoEnergieland" in Burgenland (Figure 1). These regions were chosen because of their pioneering role as model "energy regions" in which we can observe how changes in the energy sector in the past two decades have promoted awareness toward energy efficiency in buildings and have fostered the diffusion of corresponding technologies.

Figure 1. Map of Austria highlighting the two study regions: the Energieregion Weiz-Gleisdorf in Styria and the ökoEnergieland in Burgenland (d-maps, 2013)

The ökoEnergieland, a region of 16 000 inhabitants, is located in South Burgenland on the border with Hungary. In 1990, the main district town of Güssing began to decrease its use of fossil fuels. In the following years, the town built local power and heating plants, including district heating networks in the town and the surrounding villages. The ökoEnergieland, an association of 17 municipalities aiming to become independent from fossil fuels by 2020, was established in 2005 (EEE Güssing, 2011). In the region, 88% of all buildings are single-family houses (Statistik Austria, 2011).

The Energieregion Weiz–Gleisdorf, located in Styria east of Graz, consists of 18 municipalities containing 41 600 inhabitants. Since its establishment in 1996, this region has completed various energy projects, e.g., innovations in passive house buildings, high-quality energy renovations for large-scale buildings, and solar technologies. The share of single-family houses in the region is 80% (Statistik Austria, 2011). The energy and climate goal of the Energieregion Weiz-Gleisdorf is to become CO_2 neutral by 2050.

2.2 Frame of the Decision Situation

Previous research on household decision-making regarding energy efficiency measures in buildings has identified numerous influence factors (Brohman, Cames, & Gores, 2009; Frederiks et al. 2015; IEA, 2008; Neij et al., 2009; Uitdenbogerd, 2007). These influences include contextual external factors, project-specific factors, involved actors and personal factors (Figure 2). External factors include regionally specific factors and policies such as relevant legislation and subsidy schemes, which are specific to each country, federal state and local community. For example, homeowners in Austria face legal restrictions when making decisions about the energy efficiency standard of their houses. Relevant in this regard are laws concerning the energy performance certificate (EPC) for buildings and the compulsory maximal heating demands for residential buildings prescribed in the zoning law of the federal states. The EPC, which has become compulsory since January 2008 for new buildings and since January 2009 for existing building stock, is issued by a certified planner or architect in the planning phase of the construction or renovation project and includes numerous building characteristics. The key figure is heating demand, which defines the energy labels that represent the following options for homeowners in our study: $A^{++} \leq 10kWh/m^2a$ (plus-energy house), $A^{+} \leq 15kWh/m^2a$ (passive house), $A \leq 25kWh/m^2a$ (ultra-low-energy house), $B \leq 50kWh/m^2a$ (low-energy house), $C \leq 100kWh/m^2a$ (conventional house), $D \leq 150kWh/m^2a$, $E \leq 200kWh/m^2a$, $F \leq 250kWh/m^2a$, and $G > 250kWh/m^2a$ (D, E, F and G represent existing building stock that was primarily constructed before 1990). This classification system does not account for the demand for hot water and/or electricity for heat pumps or for fans that may be required. The energy standard is solely defined on the basis of each building's heating demand in kWh/m^2a and therefore mainly indicates the thermic isolation quality of the building envelope.

In addition, the maximal heating demand for buildings [kWh/m^2a] is restricted by the required maximal heat transfer coefficients [W/m^2K] for walls, ceilings, windows or doors. The required heating demand was developed differently in the federal states of Styria and Burgenland (Table 1). According to Table 1, the labels A^{++}, A^{+}, A, B and C are decision options in Styria for new buildings and comprehensive renovations; however, since 2010 in Burgenland, the label C is no longer allowed for new buildings but is allowed for renovated houses. The influence of regionally specific factors is diverse, including available local energy infrastructure such as gas pipelines and district heating networks, locally available subsidies, awareness building projects and energy agencies. In the case of the selected study regions, regional management is an additional factor that might foster the implementation of more energy efficient buildings in the future. Project-specific factors, including the geographical location, the project type (new building or renovation), the year of project execution, and space constraints are also relevant because these factors narrow the decision options regarding the use of locally available subsidies or connections to the local district-heating network.

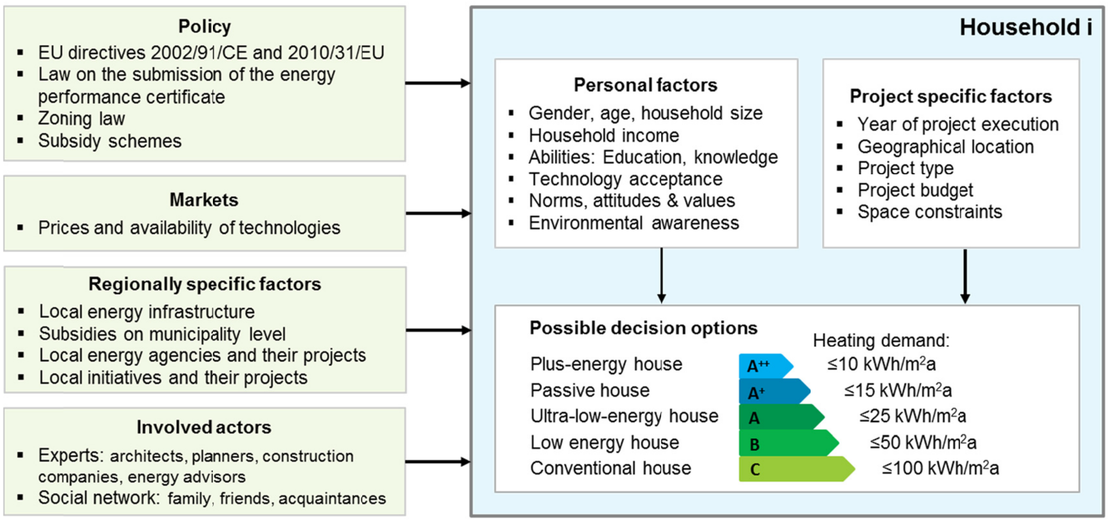

Figure 2. Overview of influence factors and possible decision options in the new building and renovation projects of single-family houses, adapted from Backhaus et al. (2011), Brohman et al. (2011)

Note. Household *i* represents a specific household with its decision-maker(s). In our study we focus on homeowners as crucial decision-makers.

Table 1. Prescribed maximal heating demand in kWh/m^{2}a for residential buildings in Styria and Burgenland

		2008 - 2009	2010 - 2012	from 2013
New buildings	Styria	78	66.5	54.4
	Burgenland	55	50	50
Comprehensive renovations	Styria	102	87.5	87.5
	Burgenland	80	70	70

Note. Data sources: Burgenländische Landesregierung, 2008; Land Steiermark, 2008; Österreichisches Institut für Bautechnik, 2007, 2011.

"Key actors" are persons involved in any stage of the decision-making process. Their role is to provide information and technical consultancy and to plan the project, during which they influence the decision-making of homeowners. These key actors can be experts such as planners, architects, building companies, installers and energy advisors. Trust or the lack of trust in these actors is an important aspect that affects the decision-making process of home-owners (International Energy Agency (IEA), 2008).

Personal factors include demographic characteristics (gender, age), household size, the level of education and psychological factors such as attachment to traditions, flexibility, openness to innovation, technology acceptance, lifestyle, values, norms, attitudes and environmental awareness, knowledge and economic aspects (Abrahamse & Steg, 2009; Backhaus et al., 2011; IEA, 2008). These aspects include household income, project budget, investment costs, operational costs, and subsidies received (Neij et al., 2009). Additional non-energy benefits such as noise reduction, improved comfort, performance, quality, reliability, and design (Stoecklein & Skumatz, 2007) and interpersonal communication within the households' social networks (McMichael & Shipworth, 2013;

Sopha et al., 2010) were found to be relevant regarding energy-related decisions.

2.3 Conceptual Framework and the Operationalization of Variables

Decision-making in the field of energy use and conservation is even more complex than often assumed, as is pro-environmental behavior in general. Although empirical evidence remains inconsistent, there is general agreement that "broad yet interrelated categories of variables may explain individual differences in household energy use" (Frederiks, Stenner, & Hobmann, 2015, p. 567). These variables include socio-demographic, psychological, contextual, and situational variables (Frederiks et al. 2015). To integrate this broad spectrum of variables into our examination of households' decision-making, we adopted an integrative approach combining Giddens' structuration theory (Giddens, 1984) with Triandis' theory of interpersonal behavior (Jackson, 2005; Triandis, 1977, 1980; Wilson & Dowlatabadi, 2007), and the integrative behavior model by Hansmann and Steimer (2015). The recently proposed integrative agent-centered (IAC) framework (Feola & Binder 2010a, b, c) provided a reasonable basis for this encompassing approach. The IAC is composed of reflexive feedback loops from decisions through a post-decisional evaluation of perceived consequences to revised decision preferences and future behavior. The IAC model thus covers a self-regulative development of the decision-making and behavior of agents (households, institutions) over time. This model was suitable for our analysis because we were interested not only in homeowners' decisions but also in measuring satisfaction with the implemented energy efficiency standards and the development of corresponding preferences and intentions for the future. We adapted the IAC framework as follows: Because we solely regarded investment-oriented measures, we excluded the concept of habits and routines. The building decisions of homeowners can be considered to be conscious decisions that are typically made only a few times in one's lifespan and thus cannot be considered habitual. We likewise omitted the measurement of affects and physiological arousal included in the IAC framework. However, attitudes have a strong affective component (like vs. dislike) and may thus correlate with affective, emotional processes.

The adapted IAC framework, as shown in Figure 3, considers (i) *personal factors* such as homeowners' attitudes, knowledge, technology acceptance, demographic variables and economic aspects including household income; (ii) *project-specific factors* that distinguish between new building projects and encompassing renovations; (iii) *contextual factors* such as political (e.g., legislation and subsidy schemes), economic (e.g., the price of a technology) and region-specific factors (e.g., subsidies); and (iv) *social influence,* exerted by communication with experts and within social networks. According to Giddens' structuration theory (1984), the building and renovation decisions and actions of households influence contextual factors and vice versa. *External aspects as cognitively represented within the decision maker* are connected to the actual external aspects through dotted lines representing a relation of probabilistic functionalism (Brunswik, 1955) in Figure 3. Arrows at the end of dashed lines represent influential feedback on the decision-maker (*Homeowner i*) and on other homeowners (*Homeowners n)*, which result from the decision that has been made.

The primary focus of the analysis is to determine which factors influence the homeowners of both regions in selecting the energy efficiency standard of their buildings. We considered the following dependent variables: (i) the actual energy efficiency standard of the house after completion of the renovation or building project (A++, A+, A, B or C); (ii) the level of satisfaction of the participants given the selected energy standard, the standard they would prefer now; and (iii) the energy standard that the homeowners would recommend to a friend.

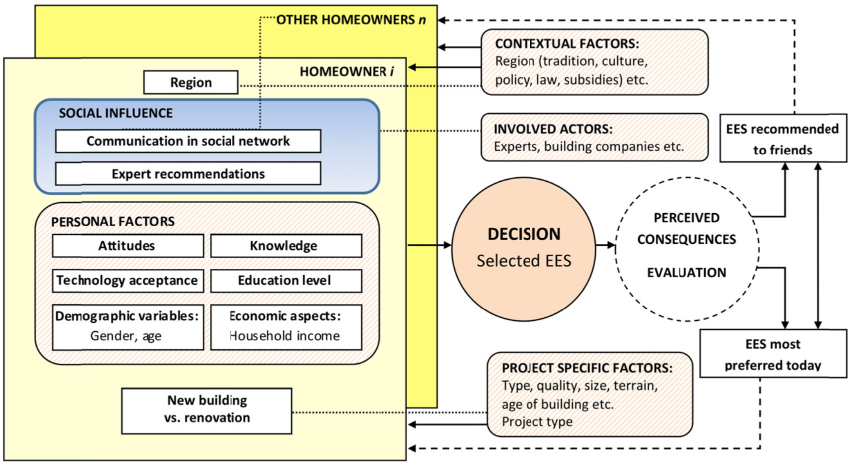

Figure 3. Conceptual analytical framework distinguishing personal factors, social factors and involved actors, in addition to contextual and project specific factors

Notes. Continuous lines represent direct influences. Dashed lines represent influence in the form of feedback following the implementation of an energy efficiency standard (EES). Dotted lines without arrows represent a referential relationship (probabilistic functionalism). *Homeowner i* represents the specific decision-maker analyzed, whereas *other homeowners n* represent other homeowners who may interact socially with the focused decision-maker.

2.4 Data Collection and Sample

We first performed problem-centered interviews with six experts and ten homeowners to obtain basic insights for constructing the questionnaire for a larger household survey, which represents the main study. The problem-centered interviews were performed between January and June 2012. The experts included an architect specializing in passive house buildings, a conventional architect, a civil engineer and researcher in the field of renewable energy, a professor specializing in energy efficiency in buildings, a financial advisor and a salesperson for a regional construction company. The homeowners in each study region were randomly selected from a list of building permits. The interviews informed the conceptualization and operationalization of the influence factors, which we consider in our analytical framework (see Figures 2, 3).

The household survey (n = 143) was conducted in February and March 2013 by trained university students in the form of questionnaire-based face-to-face paper and pencil interviews. The interviews were conducted at the homeowners' homes and lasted an average of approximately 35 minutes. The obtained energy standards of the newly built or renovated houses of the participants from the two study regions are shown in Table 2. As seen in the table, our study predominantly investigated decisions in the context of new building projects (77% of projects) and a considerably smaller share in the context of renovation projects (23%). Therefore, our findings may represent decisions on new buildings more thoroughly than decisions on renovation projects. However, the number of renovation projects in our sample appeared to be too small for a separate analysis using the basic regression model explained below.

The questionnaire was based on the analytical framework presented above and considered questions in the following four areas: (i) personal factors; (ii) project-specific factors; (iii) contextual factors; and (iv) social influence. The individual items and combined scales to assess these factors are described in Table 3.

The sample was drawn from a list of building permits from 2008 to 2013. In the Energieregion Weiz-Gleisdorf, the majority of municipalities (14 out of 18) supported the collection of the interviews by asking homeowners by phone to participate in the survey. The result was a list of 120 homeowners, of which 96 (80%) were then interviewed. The actual number of building permits was 902 (478 new building projects and 424 renovation projects); thus, we covered 11% of the projects. In the ökoEnergieland region, the cooperation with the region was not as widespread – only 5 of the 18 municipalities provided the addresses of homeowners. Consequently, we obtained 116 addresses of homeowners, of whom 47 (41%) were interviewed. Because the total number of projects was not provided for the ökoEnergieland, the coverage rate of our survey cannot be determined.

Table 2. Chosen energy standards in building and renovation projects[1] in the two study regions

	A^{++}	A^{+}	A	B	C	Sample size (*n*)
Building projects	**1.0%**	**3.1%**	**12.2%**	**69.4%**	**14.3%**	**98**
Energieregion Weiz-Gleisdorf	1.3%	2.7%	10.7%	73.3%	12.0%	75
ökoEnergieland	0%	4.3%	17.4%	56.5%	21.7%	23
Renovation projects	**0%**	**0%**	**3.4%**	**55.2%**	**41.4%**	**29**
Energieregion Weiz-Gleisdorf	0%	0%	0%	61.5%	38.5%	13
ökoEnergieland	0%	0%	6.3%	50.0%	43.8%	16
All projects	**0.8%**	**2.4%**	**10.2%**	**66.1%**	**20.5%**	**127**

[1] Based on our sample, we considered only new building projects and larger renovations in which more than 25% of the surface of the building was renovated (Bundeskanzleramt, 2015).

In Table 4 we summarize the socio-demographic and economic characteristics of households from the sample. The age of the interviewees ranged from 30 to 55, and a clear majority (79%) of the participants were males. The subsamples from the two regions were similar in their gender distribution and with respect to the income and education levels of the participants. However, there was a significant difference between the two regions with respect to the age of the participants. Respondents from the ÖkoEnergieland (M = 43.7 years) were on average significantly older than those from the Energieregion Weiz-Gleisdorf (M = 39.4 years).

2.5 Analyses Performed

We first examined differences in the potential influential factors between homeowners who selected different energy efficiency standards. To effectively compare large subgroups in this regard, the following three levels of dependent variables were distinguished:

1 = homeowners with conventional houses (C),

2 = homeowners with low-energy houses (B) and

3 = homeowners with plus-energy houses (A^{++}), passive houses (A^{+}) or ultra-low-energy houses (A)

For each potential influence factor, two tests were computed. The first series of tests straightforwardly compared the three groups with respect to each influence factor. For this purpose, Kruskal Wallis tests, or in cases of dichotomous factors, Chi-square tests were applied. In addition, the rank correlation between each factor and the selected energy efficiency standard (1, 2, 3) was computed to test for monotonous increases or decreases over the three ordered standards.

Thereafter, we conducted a multiple regression analysis, which uses potential influential factors to predict the exact energy efficiency level selected. To perform this multiple regression at a metric-dependent variable representing the energy efficiency standards, we substituted the five levels from C to A^{++} by the numeric value of the upper bounds of these energy efficiency classes ($A^{++} \leq 10\text{kWh/m}^2\text{a}$, $A^{+} \leq 15\text{kWh/m}^2\text{a}$, $A \leq 25\text{kWh/m}^2\text{a}$, $B \leq 50\text{kWh/m}^2\text{a}$, $C \leq 100\text{kWh/m}^2\text{a}$). Because it is advisable not to use a large number of predictors in a multiple regression if the sample size is moderate, we only included those independent variables in the basic regression model that were significantly related with the grouping according to one or both of the previous bivariate analyses. Subsequently, we examined whether the inclusion of any single additional previously non-significant variable in the linear regression function would substantially increase the goodness of fit.

We further investigated the satisfaction of the homeowners with the implemented energy efficiency standards, the currently preferred energy efficiency standards, and energy efficiency standards recommended to a friend. All statistical analyses were performed using SPSS Version 21.

Table 3. Description and measurement of possible factors (independent variables) influencing homeowners' decisions on energy efficiency standards

Variable	Description and scale	Survey questions
Attitude	Importance of energy efficiency of the house (Scale: 1 = *not at all* to 5 = *very important*)	How important to you was the energy efficiency of your house in the planning phase of the project?
Technology acceptance	Acceptance of passive houses (Scale: 1 = *not at all true* to 5 = *absolutely true*)	The energy saved in a passive house compensates the initial investment. A passive house contributes to environmental

	Acceptance of ventilation systems with heat recovery (Scale: 1 = *not at all true* to 5 = *absolutely true*) Index: Average rating for the items	protection. A passive house is a healthy home. A passive house is a comfortable home. Ventilation systems with heat recovery are still too prone to failure.[a] A ventilation system with heat recovery is good for the health of the residents.
General knowledge (about construction and renovation issues)	Number of information channels used for information gathering about construction and renovation issues (Scale of items: 0 = *no,* 1 = *yes*) Index: Sum of items	In the orientation phase of your building or renovation project, did you …? *i)* visit a fair devoted to construction/renovation? *ii)* read construction guide books? *iii)* consult the internet? *iv)* consult your family, friends or neighbors? *v)* consult an energy advisor? *vi)* consult a subsidy office?
Specific knowledge about energy efficiency standards	Knowledge about energy efficiency standards (Scale of items: 0 = *no,* 1 = *yes*); Index: Highest EES with positive response (C = 1, B = 2, A = 3, A+ = 4, A++ = 5)	About which energy efficiency standards for houses did you inform yourself? (C, B, A, A+, A++)
Expert recommendations	Recommendation of expert (architect, builder, engineer) about the energy efficiency standard for the house Index: Highest energy efficiency standard recommended by expert (C = 1, B = 2, A = 3, A+ = 4, A++ = 5)	Did an expert involved in the planning of your house give you a recommendation about energy efficiency standards? (yes vs. no) Which EES did he/she recommend? (C, B, A, A+, A++)
Social network	Scale of items: 0 = *no person*, 1 = *one person*, 2 = *two persons*, 3 = *three or four persons*, 5 = *more than five* Index: Average value of items	How many people do you personally know who ...? *i)* recently renovated their homes energy-wise? *ii)* recently built an energy efficient house? *iii)* live in a passive house?
Project type	Renovation, modification (= 0) or new building (= 1)	Which type of building or renovation project did you accomplish? - new building, new building replacing an old building - modification or renovation of existing building
Region	Energieregion Weiz-Gleisdorf (= 1), ökoEnergieland (= 2)	
Subsidies A (yes, no) Subsidies B number	Scale A: 0 = *none*, 1 = *yes, one or more subsidies* Scale B: Number of different subsidies received	Have you benefitted from energy related subsidies on the federal, provincial, community level? – From which ones?
Year of implementation	Scale = Year	When did you renovate, modify or newly build the house?
Demographic variables, Economic potential	Age, gender, education level, yearly household income (economic potential)	(See Table 4 for scales)

[a] Item was inversely poled for the statistical analyses, such that high ratings reflect a high acceptance of ventilation systems with heat recovery.

EES: Energy efficiency standard

Table 4. Demographic variables, education level and net household income of the survey participants

	Energieregion Weiz-Gleisdorf		Öko-Energieland		Total	Comparison of regions Significance
	$n = 96$		$n = 47$		$n = 143$	
Gender (%)- male - female	75.0 25.0		87.2 12.8		79.0 21.0	Chi-square test $p = .091$
Age (*M*, (*SD*))	39.4	(10.1)	43.7	(11.6)	40.7 (10.7)	t-test, $p = .039$*

Net income of household (categories 1 to 6, valid %)				
< 20.000€	8.0	11.1	9.0	Mann-Whitney U-test, $p = .112$
20.000€ - 32.000€	21.3	33.3	25.2	
32.000€ - 40.000€	28.0	25.0	27.0	
40.000€ -50.000€	17.3	11.1	15.3	
50.000€ - 65.000€	12.0	16.7	13.5	
> 65.000€	13.3	2,8	9.9	
Non-response (*n*, (%))	21 (21.9)	11 (23.4)	32 (22.4)	---
Highest completed education (categories 1 to 3, valid %)				
Compulsory school, basic vocational school/ formation	33.3	39.1	35.2	Mann-Whitney U-test, $p = .364$
High school, higher vocational school/ formation	35.4	37.0	35.9	
College, university	31.3	23.9	28.9	
Non-response (*n*, (%))	0 (0)	1 (2.1)	1 (0.7)	---

* $p < .05$, significant difference

3. Results

3.1 Selected Energy Efficiency Standards and Potential Influential Factors

Only 13.2% of the buildings built or renovated during the period from 2005 until 2013 by the survey participants had an energy efficiency standard of A (including A^+ and A^{++}), 66.1% were low-energy houses (B), and 20.5% were of conventional standard (C). As Table 5 shows, there was no significant difference between the two study regions in this regard, but newly built houses turned out to be significantly more energy efficient than renovated buildings. For example, averaged over both regions, the conventional standard (C) was quite rare for new building projects (14.3%), whereas this standard still encompasses 41.4 % of renovated houses. Ultra-low energy standards were realized in 12.2% of the new buildings but only in 3.4% of the renovations, whereas plus-energy houses (A^{++}) and passive houses (A^+) were chosen only in 4.1% of new building projects and not at all in renovation projects (Table 2).

In addition to the *project type* (new building = 1), the attitude of the homeowners, their specific knowledge of energy efficiency standards, and the highest energy efficiency standard recommended by experts were positively related to the actual energy efficiency standards of the houses (Table 5). The age of the respondents was also positively correlated with the actual energy efficiency standards, which means that older participants have more energy efficient houses. The rank correlations of factors, which were found to be significantly related to the selected energy efficiency standards, are provided in Table 5. The highest energy efficiency standard recommended by experts correlated with $r = .56$ substantially and highly significant ($p < .001$) with the selected energy efficiency standard. This correlation is based on the answers of 59% of homeowners who received a corresponding recommendation for their project from one or several experts. For 2.7% of them, the plus-energy house (A^{++}) was the highest recommended energy efficiency standard, followed by 13.3% for the passive house standard (A^+), 17.3% the ultra-low-energy house (A), 58.7% for the low-energy house (B) and 8% for a conventional house (C). Thus, a majority of experts recommended the moderate standard B.

Table 5. Comparison of three energy efficiency standard groups with respect to influential independent variables

	Group 1: Conventional houses (C)		Group 2: Low energy houses (B)		Group 3: Ultra-low-energy(A), Passive (A^+), Plus-energy (A^{++})		Total (All groups)		Rank correlation
Number of cases (n, %)	26	20.5 %	84	66.1 %	17	13.4 %	127	100 %	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*r*
Personal psychological									
Attitude	3.81	(0.85)	4.14	(0.76)	4.35	(0.79)	4.07	(0.84)	.22*
Technology acceptance	3.27	(0.68)	3.33	(0.68)	3.50	(0.83)	3.37	(0.69)	.09
General knowledge	4.23	(1.27)	4.46	(1.63)	4.18	(2.04)	4.33	(1.61)	.04

Specific knowledge	1.42	(1.81)	2.56	(1.87)	3.12	(1.83)	2.40*	(1.92)	.25**
Social interaction/ network									
Expert recommendation on EES: - No % (= 0)	42.3%		40.5%		29.4%		40.9%	p = .656[a]	.07
- Yes % (= 1)	57.7%		59.5%		70.6%		59.1%		
Highest EES recommended by experts (if any)	1.73	(0.59)	2.44	(0.81)	3.50	(0.85)	2.44***	(0.92)	.56***
Social network	2.41	(0.81)	2.52	(0.87)	2.65	(0.82)	2.52	(0.85)	.08
Demographic variables									
Age	36.7	(9.1)	41.0	(10.4)	43. 7	(12.5)	40.5*	(10.5)	.19*
Gender: - male (= 1)	80.8%		76.2%		88.2%		78.7%	p = .521[a]	-.03
- female (= 2)	19.2%		23.8%		11.8%		21.3%		
Household income (Mean category)[b]	3.38	(1.4)	3.19	(1.5)	3.75	(1.5)	3.30	(1.5)	.03
Education level (Mean category)[b]	2.0	(0.8)	2.0	(0.8)	1.8	(0.8)	2.0	(0.8)	.07
Context, project									
Year of implementation	2009.7	(2.1)	2009.6	(1.8)	2009.8	(2.6)	2009.7	(2.0)	.04
Region									
Weiz-Gleisdorf (= 1)	53.8%		75.0%		64.7%		69.3%	p = .113[a]	.10
ÖkoEnergieland (= 2)	46.2%		25.0%		35.3%		30.7%		
Project type									
Renovation (= 0)	46.2%		19.0%		5.9%		22.8%	p< .01[a] **	.29***
New building (= 1)	53.8%		81.0%		94.1%		77.2%		
Subsidies received for project									
- No (= 0)	11.5%		22.6%		35.3%		22.0%	p = .181[a]	-.16
- Yes (= 1)	88.5%		77.4%		64.7%		78.0%		
Number of different subsidies received for project	2.3	(1.3)	2.1	(1.7)	1.8	(1.7)	2.1	(1.6)	-.09

* $p < .05$, ** $p < .01$, *** $p < .001$; Column "total": Analysis of differences among the means of the three groups using Kruskal Wallis tests. Last column: Rank correlations testing linear associations

[a] Chi-square tests, df = 2;

[b] For the categories, see Table 4.

A moderate but significant correlation of r = .25 (p < .01) was found for the specific knowledge of the homeowners. This variable was defined as the highest energy efficiency standard homeowners informed themselves. In total, 67.7% of the homeowners informed themselves about one or several energy efficiency standards. The results on these energy efficiency standards was 19.8% for the plus-energy house (A^{++}), 45.3% for the passive house (A^{+}), 8.1% for the ultra-low-energy house (A), 23.3% for the low-energy house (B) and only 3.5% for the conventional house standard (C).

The correlation between the attitude of the homeowners and the selected energy efficiency standard was r = .22. The average value of M = 4.1 on the corresponding five-point rating scale (1 = *not at all important*, 5 = *very important*) reflects that the energy efficiency of the house was "important" to the homeowners.

The technology acceptance (M = 3.4) was considerably lower and not significantly related to the actual energy efficiency of the house. The latter was also true for the variable general knowledge, which captured how many different sources of information were consulted for the building or renovation project. Among these sources of information, consultations with family and friends (87%) were mentioned most frequently, followed by the internet (78%), visiting a construction fair (77%), reading construction guidebooks (53%), consultation at a subsidy office (53%) and consultation with an energy advisor (33%). Additional ratings for the importance of the different sources of information on five-point scales (1 = *not at all important*, 5 = *very important*) were given from those participants who used a specific source of information. These ratings were not considered in the general knowledge index. The rank order of these ratings was as follows: consultations with family and friends (M = 4.1) and the internet (M = 3.9) received the highest importance ratings, followed by consultation at a subsidy office and reading construction guidebooks (both M = 3.6), consultation with an energy advisor (M = 3.5), and visiting a construction fair (M = 3.3).

Whether homeowners received subsidies was also not significantly related to the selected energy efficiency standard. This finding may be explained by the rather low variance of this variable because a majority (78 %) of homeowners in our study obtained subsidies. However, the homeowners who received subsidies were also asked how important the subsidies were in the implementation of the project. A majority of the respondents judged the obtained subsidies as *highly important* (25%) or *important* (26.9%). The other categories were *partially important* (18.5%), *not important* (13%), and *not at all important* (16.7%). Homeowners were also asked whether they would have implemented a higher energy efficiency standard if a subsidy or a higher subsidy had been available. Approximately 34.3% answered "*yes,*" 15.7% "*perhaps,*" and 50% "*no.*"

3.2 Multiple Regression Analysis for Predicting Energy Efficiency Standards

The factors that we assumed would influence homeowners'decisions on energy efficiency were examined via a multiple regression analysis. For the selected energy standard, a multiple regression was conducted using those variables as predictor variables, which differed between (or were correlated with) the three levels of energy efficiency standards of the houses according to the previous analyses shown in Table 5. Any missing values of single predictor variables for specific cases were estimated by the overall mean of the variable for this analysis. The dependent variable was a metric value representing the selected energy efficiency standards (see Section 2.5). The prediction equation of the basic regression model was accordingly formulated as follows:

$Y = b_0 + b_1$ * Attitude + b_2 * Specific knowledge + b_3 * (highest) Expert recommendation + b_4 *Age + b_5 * Project type (renovation = 0 vs. new building = 1) (1)

This prediction model was highly significant ($p < .001$) with multiple $R = 0.56$, which means that $R^2 = 31\%$ of the variance in the dependent variable could be explained (adjusted $R^2 = 0.28$). The predictor variables *highest expert recommendation* ($\beta = -0.35, p < .001$) and *project type* ($\beta = -0.24, p < .01$) proved to be significant, whereas *attitude* ($\beta = -0.16, p = .054$), *specific knowledge* ($\beta = -0.15, p = .086$) and *age* ($\beta = -0.14, p = .075$) were slightly above the significance threshold ($p < .1$), but still not significant. This result means that the latter variables did not contribute significantly to the prediction of the selected energy efficiency standard, when expert recommendation and project type were considered, even though they were shown to be significantly related to the energy efficiency standard in the bivariate analysis (Table 5). None of the other variables included in Table 5 was found to be significant when included as additional predictors in the multiple regression, and none led to a noticeable increase in the adjusted R^2 (for all additionally included variables, adjusted $R^2 \leq 0.29$).

The basic multiple regression model including the significant predictors and those with $p < .1$ thus resulted in the best prediction model. This prediction model is depicted in the left half of Figure 4, which refers to the integrative agent-centered framework of Figure 3. The model thus also illustrates how preferences are revised in connection with the evaluation of the project, thus leading to distinct recommendations to others (as shown in the right side of Figure 4) as investigated in the two subsequent sections.

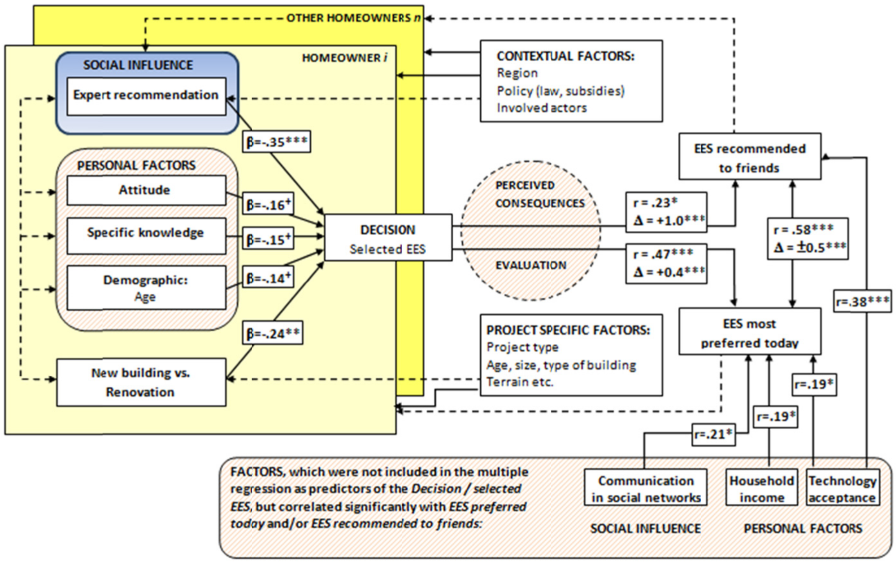

Figure 4. Significant relationships within the modified integrative agent-centered analytical framework

Notes. $^{+}p < .1$; * $p < .05$, ** $p < .01$, *** $p < .001$; significance levels of β (standardized β-weights of multiple regression with metric representation of energy efficiency standards: A^{++} = 10kWh/m^{2}a, A^{+} = 15kWh/m^{2}a, A = 25kWh/m^{2}a, B = 50kWh/m^{2}a, C = 100kWh/m^{2}a; overall model: multiple $R = 0.56$, $p < .001$), r (Spearman rank correlations), and Δ (Wilcoxon test comparing ranks) difference values refer to average values on five-point scales representing the energy efficiency standards from C = 1 to A^{++} = 5. The *homeowner i* represents the specific decision-maker analyzed and *homeowners n* represent other homeowners. EES: Energy efficiency standard.

3.3 Satisfaction with the Selected Energy Standard

The satisfaction of the homeowners with the selected energy efficiency standards was assessed using five-point scales in four items addressing i) energy use, ii) investment costs, iii) continuous costs and iv) comfort (1 = *not at all satisfied* to 5 = *highly satisfied*). The highest satisfaction was on average reported for comfort ($M = 4.7$, $SD = 0.54$), followed by energy use ($M = 4.6$, $SD = 0.59$), continuous costs ($M = 4.5$, $SD = 0.62$) and investment costs ($M = 4.2$, $SD = 0.92$). This finding reflects high satisfaction rates on average. The rank correlations between these ratings and the implemented energy standards of the house were all very low and not significant. This result was also true for an index representing the average of all four items measuring homeowners' satisfaction.

3.4 Most Preferred Energy Efficiency Standard Today and Recommendation to Friends

The homeowners were asked whether they would implement the same standard, a higher standard or a lower energy efficiency standard if they were to build a new house or to renovate their house now. Approximately 75.9% said that they would implement the same energy efficiency standard that was implemented in their project, 22% would today chose a higher energy efficiency standard and only 2.1% would implement a lower energy efficiency standard. These responses reflect considerable satisfaction with the implemented energy efficiency standard but also some revision of preferences in the direction of higher standards. If implementing a project today, 35.2% of the homeowners indicated they would prefer an energy efficiency standard of A, A^{+} or A^{++} (18%, 10.9%, 6.3%, respectively), whereas only 13.4% of the homeowners had actually implemented one of these higher standards in their houses in the previous decision. The homeowners' recommendations for friends were even more ambitious: 56.9% of the homeowners would recommend an A, A^{+} or A^{++} standard to a friend (26.2%, 21.5%, 9.2%, respectively). The energy efficiency standards recommended to a friend were significantly higher than the ones preferred today (Wilcoxon-test, $p < .001$), and both were significantly higher than the implemented energy efficiency standard (both Wilcoxon-tests, $p < .001$; Figure 4). When considering the energy efficiency standards on a five-point scale from 1 = C to 5 = A^{++}, the average values were $M = 2.0$ for the implemented energy efficiency standard, $M = 2.5$ for the energy efficiency standard preferred today, and $M = 2.9$ for the one recommended to a friend. The rank correlation between the implemented energy efficiency standard and the most preferred energy efficiency standard today was with $r = .47$ medium and highly significant ($p < .001$). The implemented energy efficiency standard and the one recommended to a friend correlated with $r = .23$, rather low but statistically significant ($p < .05$). The highest correlation was observed between the most preferred energy efficiency standard today and the one recommended to a friend ($r = .58$, $p < .001$). Homeowners' satisfaction with the selected energy efficiency standards was not significantly correlated with the most preferred and recommended energy efficiency standards.

Finally, we analyzed the bivariate rank correlations between the variables technology acceptance, social network, household income, education level, and use of subsidies, and the energy efficiency standard most preferred today and recommended to a friend. In our study, these variables were found to be unrelated to the homeowners' selection of energy efficiency standards (Table 5). However, previous studies and the problem-centered interviews of our pre-study indicate that these variables could play a role in preferences regarding energy efficiency measures. The following significant findings emerged (Figure 4): technology acceptance was significantly positively related to both the energy efficiency standard preferred today ($r = .19$, $p < .05$) and recommended to a friend ($r = .38$, $p < .001$); and the variable social network ($r = .21$, $p < .05$) and the household income ($r = .19$, $p < .05$) were both significantly correlated with the energy efficiency standard preferred today.

4. Discussion

As shown in the review of Frederiks et al. (2015) on factors influencing household energy usage, several general tendencies can be observed. However, because of inconsistencies between studies, it is necessary to conduct focused studies that reveal the complex interplay of relevant variables within specific groups and contexts. The primary focus of this study was to examine the factors influencing homeowners' decision-making about the energy efficiency standards of their buildings in two regions of Austria. We also analyzed homeowners' satisfaction with the implemented standards and the resulting current preferences and intentions for recommending energy efficiency standards to others. In the following section, we discuss our findings and integrate them with the results of previous studies to draw practical conclusions for facilitating and promoting higher energy efficiency standards of buildings for the study regions. The integration with previous findings shall also establish a basis for evaluating the transferability of our conclusions to other decision contexts and regions, and thus, to add to the general knowledge base on household decision-making on energy efficiency measures.

The household survey revealed that the majority of homeowners (66%) selected low-energy houses (standard B), followed by the conventional standard C (21%) and 13% total for a plus-energy house (A^{++}), passive house (A^{+}) or ultra-low-energy house (A). Based on our findings, the two most important factors in homeowners' decision-making were expert recommendations and the project-specific differentiation between new building projects and renovations. In addition, *attitudes in relation to energy efficiency standards of buildings*, *specific knowledge of energy efficiency standards* and the *age* of the respondents were significantly related to the selected energy efficiency standards.

The higher energy efficiency of new buildings relative to the energy efficiency of renovations is understandable because the implementation of new technologies can be planned from the beginning for new buildings but is constrained by the existing building substance in the case of renovations. A study by Stieß and Dunkelberg (2013) suggests that in Germany, renovation activities undertaken by homeowners result in only subtle improvements in energy efficiency and far less than what would be technically viable.

In a study on the adoption of energy efficiency measures in detached houses, Nair, Gustavsson, and Mahapatra (2010b) found that experts (companies, installers and energy advisers) were an important source of information for homeowners. Backhaus et al. (2011), examining the role of real estate agents and other actors in the building sector, found that practical recommendations from such experts were found helpful for homeowners who required additional information and advice. However, because the experts in our study mostly recommended energy efficiency standard B, the full potential of their recommendations for promoting more efficient energy standards was presumably not realized. The recommendations of our experts instead resemble the findings of Guy and Shove (2000), who examined the role of designers, building companies and other relevant actors and found that energy conservation is often not of primary importance as long as the criteria of existing building regulations are met.

As in our study, previous studies have also identified specific knowledge as crucial for the implementation of energy efficiency standards. Banfi et al. (2008) suggest that a lack of knowledge regarding the advantages of the efficiency measures prevents corresponding investments. Similarly, a lack of knowledge about technologies related to energy efficiency can represent a barrier to energy saving (Tuominen & Klobut, 2009). This lack has been identified as a barrier in a study by Nair et al. (2010b), in which half of the respondents did not know or knew little about energy efficiency measures. Backhaus et al. (2011) examined homeowners' knowledge about the energy performance certificate (EPC), concluding that policy-makers should provide more useful and trustworthy information. According to Adjei, Hamilton and Roys (2011), receiving information and talking with energy professionals can promote energy efficiency improvements. Similarly, Tambach Hasselaar, and Itard (2010) recommend policies for knowledge transfer among homeowners and experts and has found, identical to our findings, that interpersonal communications are an important source of information. In line with previous studies, the results of our survey suggest that there is still a need to improve both homeowners' and experts' knowledge to foster the most energy efficient building standards.

Our findings also support previous studies underscoring the importance of homeowner attitudes. Stern (2000) suggests that attitudes are a causal variable in pro-environmental behavior. Various studies show that pro-environmental attitudes foster pro-environmental behavior (Herring, Caird, & Roy, 2007; Jackson, 2005). Mahapatra and Gustavsson (2008) suggest that the diffusion of heating systems depends on people's attitudes. In a study by Herring et al. (2007), concerns about saving energy and the environment were identified as factors promoting the adoption of energy efficiency measures.

Contrary to our findings, previous studies have found technology acceptance to be a crucial factor for decisions related to energy efficiency (Tambach et al., 2010). In his ABC theory, Stern (2000) considers constraints provided by technology, available technology and the introduction of new technology to be limiting factors of environmentally relevant behavior. The acceptance of building technologies such as plus-energy and passive houses was found to be an indicator of intentions for their use in a previous study on the energy region Energieregion Weiz-Gleisdorf (Schaffer et al., 2012). Although our results confirmed that the acceptance of technologies related to energy efficiency is still moderate among homeowners, we did not observe a significant relationship between technology acceptance and the implemented energy efficiency standards. One reason for this finding may be the time gap between the former decisions and the assessment of technology assessment in the survey. Another explanation may be the scope of the items used to measure technology acceptance; their content was constrained to passive house technologies and ventilation systems for heat recovery (Table 3). Nevertheless, we found significant positive relationships between technology acceptance and current preferences for energy efficiency standards and with intentions for recommending energy efficiency standards to others.

Whereas age does often not show an influence on energy use and conservation (Frederiks et al. 2015), the age of respondents was also significantly related to the selected energy efficiency standards in our study, with older participants having the more energy efficient houses. This finding is also at odds with a study by Nair et al. (2010a) that revealed that better educated residents below the age of 55 years were more likely to adopt investment energy efficiency measures than older residents.

Two further aspects of our study that conflict with previous findings (see also Frederiks et al. 2015) are the lack of influence of homeowners' income and education level on energy efficiency decisions. A study by Rohracher and Ornetzeder (2001) suggested that residents of "ecological buildings" tend to be well-educated with high incomes and good access to information. Such homeowners can be described as innovators and early adopters (Rogers 1995; 2003). Nair et al. (2010b) found that homeowners emphasized economic aspects such as investment costs and annual energy costs when implementing energy efficiency measures. Furthermore, a household survey on energy labels in buildings showed that on average, households with a higher income more often had an EPC (Adjei et al., 2010). Although our study confirmed a positive relationship between income and the revised preferences for energy efficiency standards today, we found no relationship with the implemented efficiency standard or influence of homeowners' education level on selected or currently preferred energy efficiency standards. Because energy efficiency has become a mainstream topic in the two Austrian energy regions in our study, it is possible that people from all socio-economic strata, not just well-educated homeowners, have considerable interest in this issue.

Today, homeowners in our sample prefer higher energy standards than the ones they previously implemented in their homes. This result suggests that there exists a corresponding trend in the two study regions towards implementing higher energy efficiency standards in buildings. This suggestion is also supported by the finding that homeowners recommend even higher efficiency standards to friends than the homeowners preferred for themselves. Based on social comparison theory (Festinger, 1954), changes in private opinions to those expressed in social interaction usually occur in the direction of norms supported by the majority, respectively towards the values supported in the cultural surrounding (Goethals & Zanna, 1979). Providing recommendations, and hence expressing opinions in favor of higher energy efficiency standards in buildings, aligns with the socio-cultural climate that has developed in the two energy regions. Because these regions adopted this role by naming themselves energy regions, renewable energy and energy efficiency are important local topics.

5. Conclusions

This paper examined the energy efficiency standards chosen by the homeowners of single-family houses in two study regions in Austria. The study specifically analyzed (i) which factors were important in the decision-making process, (ii) how satisfied the homeowners were concerning the implemented standards, and (iii) which standards the homeowners prefer now and would recommend to others.

The results suggest that experts' recommendations and homeowners' personal attitude and specific knowledge related to energy efficiency standards are key factors in decision-making. To promote efficient energy standards for residential buildings, policymakers should focus accordingly on experts involved in the building and renovation projects. Furthermore, information on energy standards, effects on well-being and costs should be made readily available to facilitate an increase in knowledge for people planning to construct a new house or renovate their existing home. Currently, the established managements of the Austrian energy regions have access to the local population through media, public events, local energy providers, energy cooperatives and schools. These outlets provide a good starting point to implement various measures to further raise the awareness concerning energy saving and energy efficiency and to promote energy efficient technologies and consequently improve their acceptance. Such activities must be continued and intensified to further the development towards sustainable development in the building sector. With regard to experts such as architects, builders, engineers, and firms involved in building and renovation projects, we propose continued and expanded training organized by the energy region's management. To foster the energy transition, interventions concerning the zoning law and subsidies for homeowners also appear to be promising. In the zoning law, for example, the maximum allowed heating demands for residential buildings are prescribed; a direct way to influence builders would therefore be to reduce the allowed upper limits more rapidly, as currently planned in favor of A^{++}, A^{+} and A houses. This requirement would thereby influence homeowners, builders and experts by encouraging them to focus on corresponding technologies.

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References

Abrahamse, W., & Steg, L. (2009). How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings? *Journal of Economic Psychology, 30*(5), 711-720. http://dx.doi.org/10.1016/j.eneco.2006.06.001

Adjei, A., Hamilton, L., & Roys, M. (2011). *A study of homeowners´ energy efficiency improvements and the impact of the Energy Performance Certificate.* Retrieved from https://www.bre.co.uk/filelibrary/pdf/projects/Final_WP5_report_Deliverable_5.2__with_appendices_July_2011.pdf

Backhaus, J., Tigchelaar, C., & Best-Waldhober, M. d. (2011). *Key findings & policy recommendations to improve effectiveness of Energy Performance Certificates & the Energy Performance of Buildings Directive*. Retrieved from http://www.ecn.nl/docs/library/report/2011/o11083.pdf

Banfi, S., Farsi, M., Filippini, M., & Jakob, M. (2008). Willingness to pay for energy-saving measures in residential buildings. *Energy Economics, 30*(2), 503-516. http://dx.doi.org/10.1016/j.eneco.2006.06.001

Bohunovsky, E. (2008). *Behavioural aspects of energy consumption in private households* (Unpublished master's thesis) Technische Universität Wien, Vienna, Austria.

Brohman, B., Cames, M., & Gores, S. (2009). *Conceptual Framework on Consumer Behaviour - With a focus on energy savings in buildings*. Retrieved from http://www.ideal-epbd.eu/index.php?action=downloads&lang=eng

Bundeskanzleramt (2015). Landesrecht Steiermark: Gesamte Rechtsvorschrift für Steiermärkisches Baugesetz, Fassung vom 11.07.2015. Retreived July 10, 2015, from https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrStmk&Gesetzesnummer=20000070

Brunswik, E. (1955). Representative design and probabilistic theory in a functional psychology. *Psychological Review, 62*(3), 193–217. http://dx.doi.org/10.1037/h0047470

Burgenländische Landesregierung (2008). Burgenländische Bauverordnung 2008 [Building law Burgenland] - Bgld. BauVO 2008.Eisenstadt, Austria: Government of the Austrian Federal State Burgenland.

D-Maps (2013). *Free maps.* Retrieved June 27, 2013, from http://d-maps.com/

EEE Güssing (2011). Regionales Energiekonzept ökoEnergieland. *Klima- und Energiemodellregionen*: *Europäisches Zentrum für erneuerbare Energie Güssing GmbH.* Retrieved April 28, 2011 from http://www.klimaundenergiemodellregionen.at

Europe´s Energy Portal (2013). *Energy statistics: Dependency.* Retrieved June 27, 2013, from http://www.energy.eu/

Feola, G., & Binder C. R. (2010a). *The integrative agent-centred (IAC) framework as a conceptual tool to investigate transition processes in local agricultural systems*. Paper presented at the First European Conference on Sustainability Transitions: Dynamics & Governance of Transitions to Sustainability, Amsterdam, the Netherlands.

Feola, G., & Binder C. R. (2010b). Why Don't Pesticide Applicators Protect Themselves? Exploring the Use of Personal Protective Equipment among Colombian Smallholders. *International Journal of Occupational and Environmental Health, 16*, 11-23. http://dx.doi.org/10.1179/oeh.2010.16.1.11

Feola, G., & Binder, C. R. (2010c). Towards an improved understanding of farmers' behaviour: The integrative agent-centred (IAC) framework. *Ecological Economics, 69*(12), 2323-2333. http://dx.doi.org/10.1016 /j.ecolecon.2010.07.023

Festinger, L. (1954). A Theory of Social Comparison Processes.*Human Relations, 7,* 117–140. http://dx.doi.org/10.1177/001872675400700202

Frederiks, E. R., Stenner, K., & Hobman, E. V. (2015). The Socio-Demographic and Psychological Predictors of Residential Energy Consumption: A Comprehensive Review. *Energies, 8*, 573-609. http://dx.doi.org/10.3390/en8010573

Giddens, A. (1984). *The constitution of society*. Cambridge: Polity Press.

Goethals, G. R., & Zanna, M. P. (1979). The role of social comparison in choice-shifts. *Journal of Personality and Social Psychology, 37,* 1469–1476. http://dx.doi.org/10.1037/0022-3514.37.9.1469

Gram-Hanssen, K., Bartiaux, F., Michael Jensen, O., & Cantaert, M. (2007). Do homeowners use energy labels? A comparison between Denmark and Belgium. *Energy Policy, 35*(5)*,* 2879-2888. http://dx.doi.org/10.1016/j.enpol.2006.10.017

Guy, S., & Shove, E. (2000). *A Sociology of Energy, Buildings and the Environment: Constructing knowledge, designing practice*. London and New York: Routledge.

Hansmann, R., & Steimer, N. (2015). Linking an Integrative Behavior Model to elements of environmental campaigns: An analysis of face-to-face communication and posters against littering. Sustainability, 7, 6937-6956. http://dx.doi.org/10.3390/su7066937

Herring, H., Caird, S., & Roy, R. (2007). *Can consumers save energy? Results from surveys of consumer adoption and use of low and zero carbon technologies Conference proceedings*. Paper presented at the ECEEE 2007 Summer study: Saving Energy - just do it! Milton Keynes: Design Innovation Group, The Open University UK.

International Energy Agency (IEA) (2008). Promoting Energy Efficieny Investments. Case Studies in the Residential Sector: International Energy Agency. Paris: International Energy Agency.

Jackson, T. (2005). *Motivating sustainable consumption: A review of evidence on consumer behaviour and behavioural change. A report to the Sustainable Development Research Network*. Guildford: Centre for Environmental Strategy, University of Surrey.

Krischan, H. (2013a). *Klimatabelle.* Retrieved June 22, 2013, from http://www.ifea.tugraz.at/hp_old/heizlast/ wertetab2.htm

Krischan, H. (2013b). *Grundgebgriffe.* Retrieved June 24, 2015, from http://www.ifea.tugraz.at/hp_old/heizlast/ grundbegriffe.htm

Land Steiermark (2008). Steiermärkisches Baugesetz. Energieeinsparungs- und Wärmeschutzverordnung 2008. LGBl. Nr. 59/1995, zuletzt in der Fassung LGBl. Nr. 27/2008. Graz, Austria: Ministry of the Austrian Federal State Styria [Amt der Steiermärkischen Landesregierung].

Lutzenhiser, L., & Shove, E. (1999). Contracting knowledge: the organizational limits to interdisciplinary energy efficiency research and development in the US and the UK. *Energy Policy, 27*(4)*,* 217-227.

http://dx.doi.org/10.1016/S0301-4215(99)00012-9

Mahapatra, K., & Gustavsson, L. (2008). An adopter-centric approach to analyze the diffusion patterns of innovative residential heating systems in Sweden. *Energy Policy, 36*(2), 577-590. http://dx.doi.org/10.1016/j.enpol.2007.10.006

Mahapatra, K., Nair, G., & Gustavsson, L. (2011). Swedish energy advisers' perceptions regarding and suggestions for fulfilling homeowner expectations. *Energy Policy, 39*(7): 4264-4273. http://dx.doi.org/10.1016/j.enpol.2011.04.043

McMichael, M., & Shipworth, D. (2013). The value of social networks in the diffusion of energy-efficiency innovations in UK households. *Energy Policy53*(0). http://dx.doi.org/10.1016/j.enpol.2012.10.039

Nair, G., Gustavsson, L., & Mahapatra, K. (2010a). Factors influencing energy efficiency investments in existing Swedish residential buildings. *Energy Policy, 38*(6): 2956-2963. http://dx.doi.org/10.1016/j.enpol.2010.01.033

Nair, G., Gustavsson, L., & Mahapatra, K. (2010b). Owners perception on the adoption of building envelope energy efficiency measures in Swedish detached houses. *Applied Energy, 87*(7)*,* 2411-2419. http://dx.doi.org/10.1016/j.apenergy.2010.02.004

Neij, L., Mundaca, L., & Moukhametshina, E. (2009). *Choice-decision determinants for the (non) adoption of energy efficiency technologies in households.* Paper presented at the Proceedings of the European Council for an Energy Efficient Economy, La Colle sur Loup, France.

Österreichisches Institut für Bautechnik [Austrian Institute for Building Technology] (2007). OIB - Richtlinie 6: Energieeinsparung und Wärmeschutz 2007. *OIB-300.6-038/07*. Vienna, Austria: Österreichisches Institut für Bautechnik.

Österreichisches Institut für Bautechnik [Austrian Institute for Building Technology] (2011). OIB - Richtlinie 6: Energieeinsparung und Wärmeschutz 2011.*OIB-330.6-094/11*. Vienna, Austria: Österreichisches Institut für Bautechnik.

Paschotta, R. (2015). Heizgradtage. In R. Paschotta, *Das RP-Energie-Lexikon*. Retrieved June 24, 2015, from https://www.energie-lexikon.info/heizgradtage.html

Plate, M., Moser, W., & Elvin, G. (2010). Marktpotenzial und Bekanntheitsgrad des Passivhauses in Österreich. In M. Paula (Ed.), *Berichte aus Energie- und Umweltforschung* (Vol. 11/2010). Wien: Bundesministerium für Verkehr, Innovation und Technologie.

Rogers, E. M. (1995). Lessons for guidelines from the diffusion of innovations. *The Joint Commission journal on quality improvement 21(7*), 324-8.

Rogers, E. M. (2003). *Diffusion of innovations* (5. ed.). New York: Free Press.

Rohracher, H., & Ornetzeder, M. (2001). Akzeptanzverbesserung bei Niedrigenergiehaus-Komponenten. Projektbericht „Haus der Zukunft“. In M. Paula (Ed.), *Berichte aus Energie- und Umweltforschung 8/2008.* Wien: Bundesministerium für Verkehr, Innovation und Technologie.

Rohracher, H., & Ornetzeder, M. (2002). Green Buildings in Context: Improving Social Learning Processes between Users and Producers. *Built Environment, 28*(1), 73-84.

Rohracher, H., & Ornetzeder, M. (2008). Wohnen im ökologischen "Haus der Zukunft": Eine Bestandsaufnahme sozio-ökonomischer Projekte im Rahmen der Programmlinie „Haus der Zukunft“. In M. Paula (Ed.), *Berichte aus Energie- und Umweltforschung 8/2008*. Wien: Bundesministerium für Verkehr, Innovation und Technologie.

Schaffer, M., Absenger-Helmli, I., Binder C. R. Eder, M., Kreuzeder, A., Kisslinger, M., Narodoslawsky, M., Orthhofer, C., Vilsmaier, U. (2012). iENERGY Weiz-Gleisdorf – Citizens supported by a stakeholder process implement intelligence to upgrade their smart urban region - *Blue Globe Report, Smart cities 09/2012*. Retrieved from https://www.klimafonds.gv.at/assets/Uploads/Projektberichte/Smart-Energy-Demo---FIT-for-SET-1.-Ausschreibung-2010/BGR092012K11NE2F00006WeizGleisdorfv1.0.pdf

Sopha, B. M., Klöckner, C. A., Skjevrak, G., & Hertwich, E. G. (2010). Norwegian households' perception of wood pellet stove compared to air-to-air heat pump and electric heating. *Energy Policy, 38*(7), 3744-3754. http://dx.doi.org/10.1016/j.enpol.2010.02.052

Statistik Austria (2011). Ein Blick auf die Gemeinde. Retrieved from http://www.statistik.at/blickgem

Stern, P. C. (2000). Toward a Coherent Theory of Environmentally Significant Behavior. *Journal of Social Issues, 56*(3), 407-424. http://dx.doi.org/10.1111/0022-4537.00175

Stieß, E., & Dunkelberg, E. (2013). Objectives, barriers and occasions for energy efficient refurbishment by private homeowners. *Journal of Cleaner Production*, *48*, 250-259. http://dx.doi.org/10.1016/j.jclepro.2012.09.041

Stoecklein, A., & Skumatz, L. (2007). Zero and low energy homes in New Zealand: The value of non-energy benefits and their use in attracting homeowners. *2007 European Council for an Energy Efficient Economy Summer Study on Energy Efficiency*. 4-5 June 2007, La Colle sur Loup, Côte d'Azur, France.

Tambach, M., Hasselaar, E., & Itard, L. (2010). Assessment of current Dutch energy transition policy instruments for the existing housing stock. *Energy Policy, 38*(2), 981-996. http://dx.doi.org/10.1016/j.enpol.2009.10.050

Triandis, H. C. (1977). Interpersonal Behaviour. Monterey, C.A: Brook/Cole.

Triandis, H. C. (1980). Values, attitudes, and interpersonal behavior. In H. E. Howe & M. M. Page (Eds.), *Nebraska Symposium on Motivation 1979* (pp. 195-259). Lincoln, Nebraska: University of Nebraska Press.

Tuominen, P., & Klobut, K. (2009). Deliverable 3.1: Country specific factors - Report of findings in WP3. Retrieved from https://www.bre.co.uk/filelibrary/pdf/projects/country_specific_factors.pdf

Uitdenbogerd, D. E. (2007). *Energy and Households: The Acceptance of Energy Reduction Options in Relation to the Performance and Organisation of Household Activities* (Doctoral thesis). Universiteit, Wageningen, Wageningen, The Netherlands.

Wilson, C., & Dowlatabadi, H. (2007). Models of Decision Making and Residential Energy Use. *Annual Review of Environment and Resources, 32*(1), 169-203. http://dx.doi.org/10.1146/annurev.energy.32.053006.141137