

THE ROLE OF ENERGY PERFORMANCE CERTIFICATES IN REDUCING THE INFORMATION BARRIERS: EVIDENCE FROM SLOVENIA

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18th IAEE European Energy Conference, The Global Energy
Transition Toward Decarbonization – a multi-scalar perspective and
transformation, Milan, 24 - 27 July 2023

Introduction and motivation

- Energy performance certificates (EPCs) are an informative measure that provides standardized information on the energy efficiency of buildings (or their parts). The energy performance is usually rated on a scale from **A (most energy-efficient)** to **G (least energy-efficient)**.
- The effectiveness of energy performance has been under-researched, especially in connection to the **financial and energy literacy** of respondents, and the **display of monetary information**.
- **Three-quarters** of the EU building stock is **energy inefficient** according to current building standards.



An overview of relevant literature

- **Energy performance certificates:** Andaloro et al. (2010), Brounen and Kok (2011), Hyland et al. (2013), Cerin et al. (2014), Murphy (2014), Fuerst et al. (2015), Olaussen et al. (2017), Marmolejo-Duarte and Bravi (2017), Li et al. (2019), Gonzalez-Caceres et al. (2020), Evangelista et al. (2020), Lakić et al. (2021)
- **Financial literacy and energy literacy:** DeWaters and Powers (2011), Brounen et al. (2013), Blasch et al. (2017), Lusardi and Mitchell (2014), Brent and Ward (2018), Blasch et al. (2019), Stadelmann and Schubert (2018), Blasch et al. (2021), Kalmi et al. (2021), He et al. (2022)

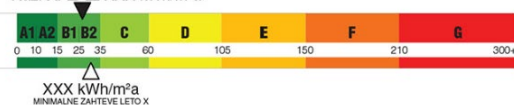
EPCs in Slovenia

ENERGETSKA IZKAZNICA STAVBE

Podatki o stavbi		Vrsta izkaznice: računska	
Št. izkaznice:	Velja do:	Vrsta stavbe: stanovanjska	Naziv stavbe:*
Identifikacijska oznaka stavbe, posameznega dela ali delov stavbe:		fotografija stavbe (obvezno vstaviti)	
Klasifikacija stavbe:			
Leto izgradnje:			
Naslov stavbe:			
Kondicionirana površina stavbe A_k (m ²)			
Parcelna št.:			
Katastrska občina:			

Potrebna toplota za ogrevanje

Razred **B2** XXX kWh/m²a



Dovedena energija za delovanje stavbe

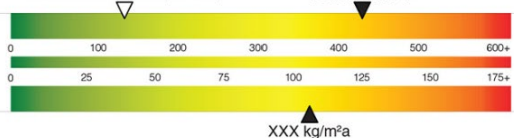
XXX kWh/m²a



Primarna energija in Emisije CO₂

SKORAJ NIČ-ENERGETSKA STAVBA (XXX kWh/m²a)

XXX kWh/m²a



Izdajatelj

Izdajatelj d.o.o. (št. pooblastila)
Ime in podpis odgovorne osebe:
Cipcija: elektronski podpis,
Datum izdaje:

Izdelovalec

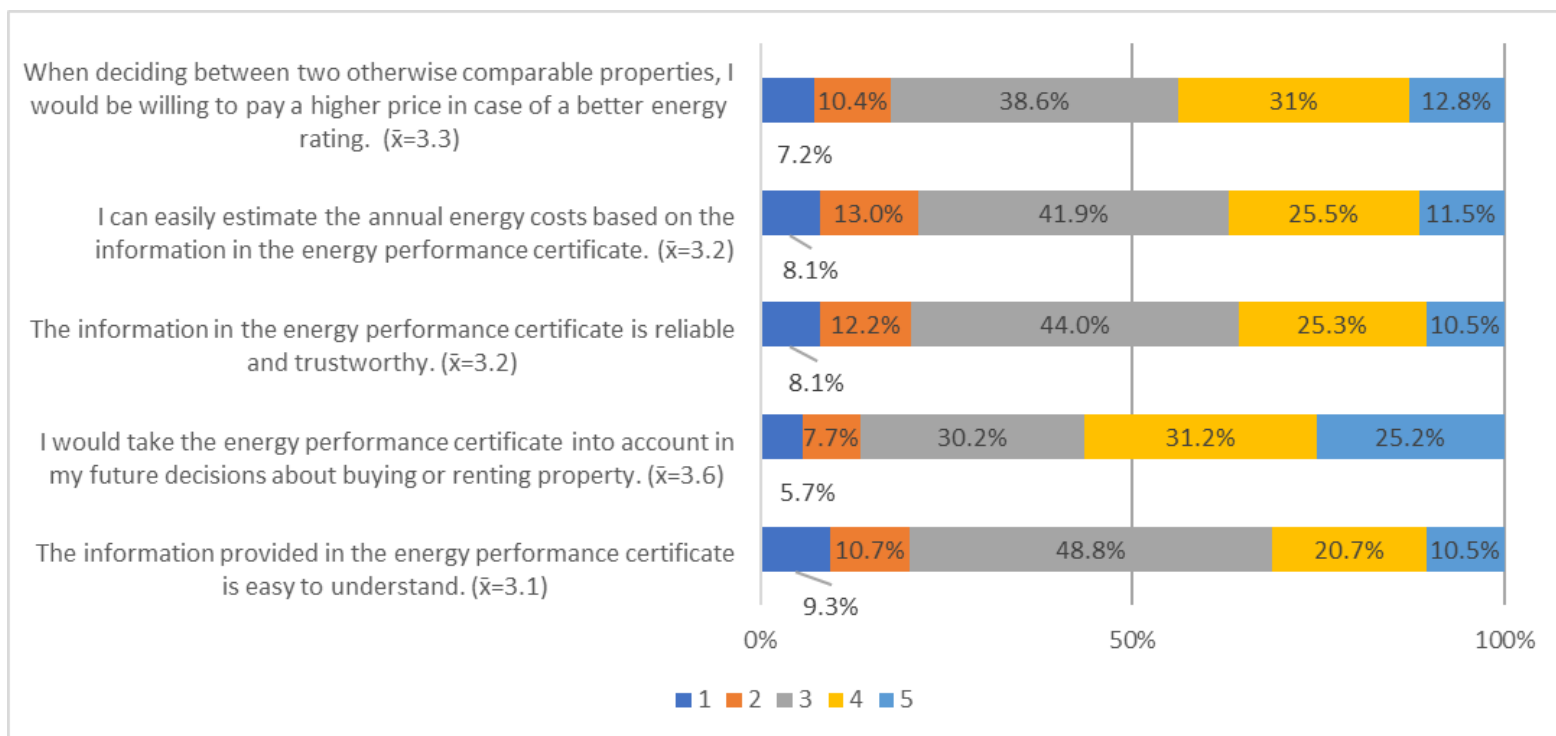
Janez Novak (št. pooblastila)
Ime in podpis:
Cipcija: elektronski podpis,
Datum izdaje:

Izdelovalec te energetske izkaznice s podpisom potrjuje, da ne obinja katerega od določil iz Energetskega zakona (Uk list RS 17/14), ki bi ni preprečevala izdelave energetske izkaznice.
Energetska izkaznica stavbe je izdelana v skladu s Pravilnikom o metodologiji izdelave in izdaji energetske izkaznice stavbe in z Energetskim zakonom (Uk list RS 17/14).

list 1/4

- **EPCs: mandatory in Slovenia** since 2013 for public buildings exceeding 250 m² and all buildings with frequent public use and a usable floor area over 500 m², as well as in the case of real estate sales and rentals of one year or longer (**with certain exceptions**).
- EPCs use a scale from A (most energy-efficient) to G (least energy-efficient), with **ratings A and B divided into subcategories**.
- The certificates provide information on the building's energy performance, issuer details, and **recommendations for cost-effective energy efficiency improvements specific to the building**.

Attitudes about EPCs



- **58.9%** stated that their home **does not have an EPC**
- **18.9%** **do not know** if their home has an EPC.

Data

- Primary data was collected from a household survey conducted in August 2020 as a part of the EU funded Care4Climate project.
- The sample includes 3,000 respondents from Slovenia, economic decision-makers in their household. The final sample includes **2,484 owners and co-owners**.
- The survey was conducted online, with the help of a market-research agency.
- Characteristics of respondents in the sample closely resemble population with respect to the region, gender and age, with a slight over-representation of individuals with higher levels of education.



Method

- **Two decisions** are modeled.
- **First:** whether **individual- related characteristics** impact the choice to **rely on the EPC** when making real estate purchasing decisions.
- **Second:** based on a **choice experiment**, we explore how **different factors** and the **display of monetary information** on the EPC affect the choice of a home with a **better energy rating** for a **price premium**, ceteris paribus.
- **Two separate probit models** are estimated, a **bivariate probit model**, and a **recursive bivariate probit model**.



Overview of explanatory variables

Variable	Mean	Std.Dev.	Min	Max
Socio-economic and individual-specific variables				
The respondent is male (0–No, 1–Yes)	0.483	0.5	0	1
Age (in years)	47.113	13.388	18	86
University education or higher (0–No, 1–Yes)	0.493	0.5	0	1
Respondent's net monthly income is larger than the median of 1,900 EUR (0–No, 1–Yes)	0.356	0.478	1	5
Energy literacy (score 0 to 5 depending on the number of correct answers)	1.093	1.244	0	5
Financial literacy (score 0 to 5 depending on the number of correct answers)	3.371	1.338	0	5
Correct total life-cycle cost calculation (0–No, 1–Yes)	0.596	0.491	0	1
Positive attitude towards energy conservation (0–No, 1–Yes)	0.491	0.5	0	1
Free-riding attitude towards energy conservation (0–No, 1–Yes)	0.092	0.289	0	1
Energy-efficient behavior (scale 1-Never to 5-Always)	3.833	0.587	1	5
The respondent would take the EPC into account in their future real estate purchase or rental decisions (0-No, 1-Yes)	0.564	0.495	0	1
Building and location-specific variables				
The surface of the apartment (logarithm of the surface in square meters)	4.633	0.535	3.401	5.991
Age of the building (in years)	41.989	19.542	4	75
Respondent lives in a single-family house (0–No, 1–Yes)	0.62	0.485	0	1
Respondent lives in a city (0–No, 1–Yes)	0.587	0.492	0	1
Energy performance certificate-related variables				
Treatment variable: respondent received monetary information on the annual energy savings (0–No, 1–Yes)	0.482	0.5	0	1
The respondent's home has an energy rating of D or worse (0–No, 1–Yes)	0.817	0.387	0	1
Change in energy rating showed in the choice experiment (1 to 5 energy 'grades')	2.762	.795	1	5
Price premium (in %)	7.069	3.541	1	20

Choice experiment design

Treatment group:

Received **monetary information** on energy savings (in EUR)

Assume that you could choose between your current home and a property that has a better energy rating as measured by the energy performance certificate, but is otherwise comparable to your current home (e.g., location, size, furnishings, year of construction, etc.). A comparison of the information provided in the energy performance certificate for the two properties is given below. The more energy-efficient property offers annual savings in energy costs of €489. **Would you be willing to pay 4% more for a more energy-efficient property?**

0 10 15 25 35 60 105 150 210 300+ (kWh/m²a)

YES
 NO

Control group:

Received only the information available on the EPC (**consumption in physical units**)

Assume that you could choose between your current home and a property that has a better energy rating as measured by the energy performance certificate, but is otherwise comparable to your current home (e.g., location, size, furnishings, year of construction, etc.). A comparison of the information provided in the energy performance certificate for the two properties is given below. **Would you be willing to pay 4% more for a more energy-efficient home?**

0 10 15 25 35 60 105 150 210 300+ (kWh/m²a)

YES
 NO



Model

- The probability that an individual will select one of the alternatives is related to the underlying utility of that alternative. Therefore, alternative 1 will be selected if its underlying utility is higher than the utility of alternative 2:

$$\text{Prob (Alternative 1 is selected)} = \text{Prob } (U_{n1} \geq U_{n2}) = \text{Prob } (V_{n1} + \varepsilon_{n1} \geq V_{n2} + \varepsilon_{n2})$$

U_{n1} - the utility obtained from alternative 1

V_{n1} , - the observable part of utility

ε_{n1} - the random error term

- Probit model equation:**

$$\text{Prob (Alternative 1 is selected}|x) = \Phi(x'_n\beta),$$

where $\Phi(x)$ denotes standard normal distribution.

Model

- **Bivariate probit model equations:**

$$y_1^* = x_1' \beta_1 + \varepsilon_1, y_1 = 1 \text{ if } y_1^* > 0, 0 \text{ otherwise}$$

$$y_2^* = x_2' \beta_2 + \varepsilon_2, y_2 = 1 \text{ if } y_2^* > 0, 0 \text{ otherwise,}$$

where:

y_1^* - the latent variable in the first probit model

y_1 - the observable dichotomous variable (1-respondent relies on the EPC when making real estate purchase decisions, 0-otherwise)

y_2^* - the latent variable in the second probit model

y_2 - the observable dichotomous variable (1-respondent selected real estate with a better energy rating, 0-otherwise)

Model

- A **recursive bivariate probit** is an extension of the bivariate probit model:

$$y_1^* = x_1' \beta_1 + \varepsilon_1, y_1 = 1 \text{ if } y_1^* > 0, 0 \text{ otherwise}$$

$$y_2^* = x_2' \beta_2 + \gamma y_1 + \varepsilon_2, y_2 = 1 \text{ if } y_2^* > 0, 0 \text{ otherwise}$$

- The observable dichotomous variable from the first equation is used as an endogenous variable in the second equation.

Results

Explanatory variables	First equation				Second equation				
	Separate probit model		Bivariate probit model		Separate probit model		Bivariate probit model		
Socio-economic and individual-specific variables									
	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.	
Gender	-0.077	0.055	-0.076	0.055	0.001	0.058	-0.014	0.057	
Age	0.001	0.002	0.001	0.002	-0.006***	0.002	-0.006***	0.002	
Education	-0.013	0.055	-0.013	0.055	0.093	0.058	0.088	0.057	
High-income dummy	-0.009	0.057	-0.010	0.057	0.134**	0.062	0.127**	0.061	
Energy literacy	0.039*	0.023	0.039*	0.023	0.000	0.024	0.008	0.024	
Financial literacy	0.104***	0.023	0.103***	0.023	0.085***	0.024	0.103***	0.024	
Life-cycle cost calculation	0.097	0.059	0.100**	0.059	0.172***	0.062	0.186***	0.061	
Positive attitude toward energy conservation	0.368***	0.055	0.369***	0.055	0.118**	0.058	0.190***	0.057	
Free-riding attitude toward energy conservation	-0.001	0.090	0.001	0.089	-0.233**	0.091	-0.225**	0.090	
Energy-efficient behavior	0.219***	0.047	0.221***	0.048	0.170***	0.049	0.210***	0.049	
Relying on EPC in future real estate purchase decisions	/	/	/	/	0.540***	0.056	/	/	
Building and location-specific variables									
Surface	/	/	/	/	0.137**	0.069	0.132**	0.067	
Age	/	/	/	/	0.002	0.002	0.002	0.002	
Single-family home	-0.024	0.054	-0.023	0.054	-0.047	0.078	-0.050	0.076	
Energy performance certificate-specific variables									
Treatment variable	/	/	/	/	-0.055	0.054	-0.053	0.052	
Current home with an energy rating of D or worse	/	/	/	/	0.233***	0.087	0.226***	0.084	
Grade change	/	/	/	/	0.024	0.050	0.027	0.049	
Price premium	/	/	/	/	-0.034***	0.012	-0.033**	0.012	
Constant	-1.291***	0.204	-1.296***	0.205	-1.351***	0.385	-1.311***	0.374	
Rho	University of Ljubljana SCHOOL OF ECONOMICS AND BUSINESS							0.337**	0.035

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Results: marginal effects of the bivariate probit model

Variables	M.E.	St.Err.
Gender	-0.023	0.019
Age	-0.001	0.001
Education	0.013	0.019
High-income dummy	0.020	0.020
Energy literacy	0.012	0.008
Financial literacy	0.046^{***}	0.008
Life-cycle cost calculation	0.060^{***}	0.021
Positive attitude toward energy conservation	0.131^{***}	0.019
Free-riding attitude toward energy conservation	-0.043	0.030
Energy-efficient behavior	0.096^{***}	0.017
Surface	0.024^{**}	0.012
Dwelling age	0.000	0.000
Single-family home	-0.015	0.021
City dummy	-0.017	0.011
Treatment	-0.010	0.010
Current home with an energy rating of D or worse	0.043^{**}	0.017
Grade change	0.005	0.009
Price premium	-0.006^{***}	0.002

Note: ^{***} $p < 0.01$, ^{**} $p < 0.05$, ^{*} $p < 0.1$

Interpretation of results

- Higher levels of **financial literacy, energy literacy, energy-efficient behavior, and moral values regarding energy conservation** positively impact the **reliance on energy performance certificates (EPCs) for purchasing decisions**.
- **Financial literacy, energy-efficient behavior, correct total life-cycle cost calculation, and a low energy rating of the dwelling** positively influence the likelihood of relying on EPCs and selecting more energy-efficient real estate.
- **A larger premium** has a negative impact on the decision to rely on EPCs and select energy-efficient real estate.
- Providing information in **monetary terms did not increase the likelihood of choosing** a home with a better energy rating, possibly due to **low energy literacy**, or the **perceived low energy savings compared to the price premium**.



Conclusions and policy recommendations

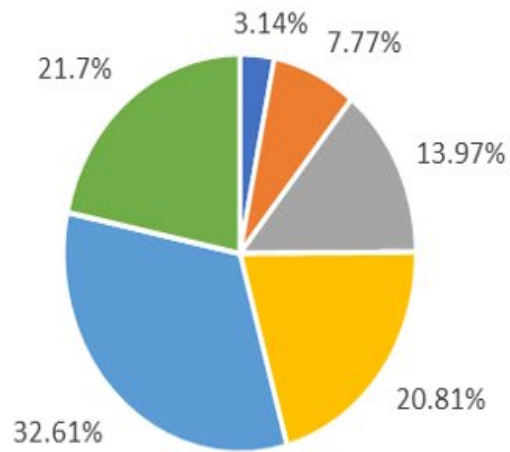
- Continue **education and information campaigns**, especially in the area of **energy literacy**.
- **Financial literacy and correct life-cycle cost calculations** are drivers of energy-efficient decision-making, along with certain dwelling characteristics (**size and the condition**).
- A **lack of knowledge and understanding** of EPCs and **incorrect life-cycle cost calculations** are **barriers** to informed decision-making.
- **Homeowners should** be better informed about the **prices and benefits** of EPCs to **motivate** them to obtain EPC.
- **Enhancing and promoting** the **recommendations** provided in EPCs for **cost-effective retrofits and energy-saving measures**.

Back-up slides

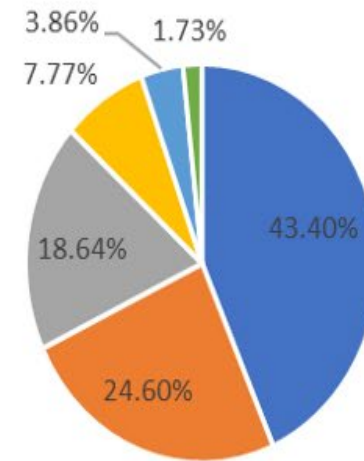


Obtained levels of financial and energy literacy (n=2484)

Financial literacy



Energy literacy



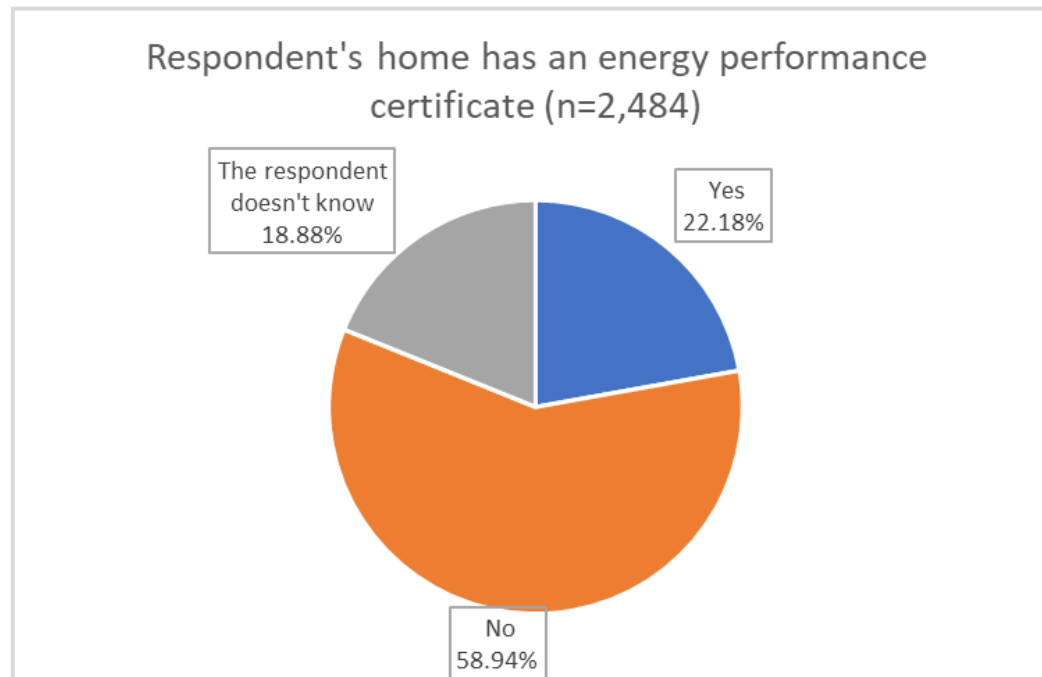
■ No correct answers ■ One correct answer ■ Two correct answers
■ Three correct answers ■ Four correct answers ■ Five correct answers

■ No correct answers ■ One correct answer ■ Two correct answers
■ Three correct answers ■ Four correct answers ■ Five correct answers

Energy literacy and financial literacy – overview (n=2484)

Answers to questions related to financial and energy literacy	Correct	Incorrect
Financial literacy: interest rate and inflation	66.55%	33.45%
Financial literacy: time value of money	70.29%	29.71%
Financial literacy: risk diversification	72.42%	27.58%
Financial literacy: mathematical knowledge	84.10%	15.90%
Financial literacy: economics classes	43.72%	56.28%
Life-cycle cost calculation	59.66%	40.34%
Energy literacy: electricity price	11.39%	88.61%
Energy literacy: average monthly electricity consumption	12.96%	87.04%
Energy literacy: electricity costs of running a washing machine	26.77%	73.23%
Energy literacy: computer electricity consumption	37.64%	62.36%
Energy literacy: energy savings from using LED lightbulbs	17.51%	82.49%

Presence of energy performance certificates



Overview of price premiums

Price premium (in %)	Full sample (n=2484)	Treatment group	Control group
Average price premium	4.58%	4.49%	4.65%
Average price premium per one unit improvement in the energy rating	1.64%	1.69%	1.59%
Average price premium if the current home has a rating of D or worse	5.07%	5.01%	5.14%
Average price premium if the current home has a rating of C or better	2.36%	2.30%	2.43%
Average price premium if residing in a single-family house	4.64%	4.41%	4.86%
Average price premium if residing in a multi-dwelling building	4.47%	4.63%	4.32%