dialogues

Energy citizenship
for a sustainable future

D4.2

Meta-analysis of existing data in relation to DIALOGUES topics

deliverable type
Report

work package
4

dissemination level
Public

month and date of delivery
Month 25 | 31 May 2023

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programme H2020 | contract number 101022585 | duration 36 months | start May 1, 2021 | end April 30, 2024

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022585

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Revision History

VERSION	DATE	REVIEWER	MODIFICATIONS
1	**22.05.2023**	**Andrea Kollman**	**MODIFICATIONS**
2	**26.05.2023**	**Giuseppe Carrus, Barbara Cardone, Chiara Massullo**	**MODIFICATIONS**

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Table of Abbreviations and Acronyms

Abbreviation	Meaning
CI	Confidence interval
FAIR	Findability, accessibility, interoperability, and reusability.
IPD	Individual participant data
OR	Odds ratio
RQ	Research question
SD	Standard deviation

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1 Executive Summary

The DIALOGUES project aims to produce knowledge relevant for making the sustainable energy transition more citizen centric. It requires the use of a range of perspectives, methods and inter- and transdisciplinary approaches to understand more of this culturally, politically, economically and geographically multifaceted topic. While a substantial part of the DIALOGUES project builds on bottom-up, participatory and qualitative approaches, we consider the advantages of combining these with quantitative methods.

Work Package 4 in the DIALOGUES project aim to build upon the work of previous research projects and examine these efforts in the light of the DIALOGUES research objectives. This report is the output of Task 4.2 in the DIALOGUES project, in which previously selected datasets are examined to provide quantitatively generalizable insights into aspects of energy citizenship and the core DIALOGUES objectives.

This report (D4.2 – Meta-analysis of existing data in relation to DIALOGUES topics) builds upon DIALOGUES report D4.1 - The state of the energy citizenship data report in which openly available datasets relevant for energy citizenship research were identified, assembled and curated. The state of the energy citizenship data report addresses concerns on the availability and quality of open data. These issues were also found to impact the potential for cross-study meta-analyses of the DIALOGUES core objectives. The aim of the current report was to identify and meta-analyse open data that can be used to provide insight into DIALOGUES core objectives. These objectives were operationalized as the associations between gender, education, climate concern, and energy saving in the home.

The decision to examine associations between gender, education, climate concern and energy saving in the home was made through an iterative process in which the core DIALOGUES objectives and the main constructs in focus in the DIALOGUES project (e.g., energy citizenship, engagement with the energy system) were first operationalized. Then datasets were examined to find survey questions that corresponded to the operationalized terms, and finally these were combined to identify areas where sufficient data was available to warrant cross-study analyses. The datasets identified in D4.1 were insufficient to answer several core DIALOGUES topics, such as the impact of energy justice, democratic engagement and participation, and energy identity. However, seven datasets contained information on gender, education, climate concern and the individual's engagement with the energy system in the form of energy saving in the home. These datasets were pooled and formed the basis for the meta-analyses.

The associations between variables were examined using two-stage individual participant data meta-analyses to arrive at an overall effect size for the pooled sample. In the first stage of the two-stage meta-analysis a specified model was fitted to the data one dataset at the time, while in the second stage these are combined into a traditional meta-analysis model. A random effects model was used as we cannot assume homogeneity across datasets due to sampling, demographic, and survey differences between datasets.

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The total sample contained seven datasets with 110 548 individuals. Slightly more than half were female (51.79%), and almost a third (31.15%) described having higher education. The sample means was 3.77 (± 1.72) for energy saving in the home, and 3.54 (± 1.63) for climate concern, using seven-point scales (0-6).

The analysis revealed significant gender differences for energy saving in the home, where women are overall more likely to score higher on energy saving questions than men. Similarly, we found a trend towards the higher educated also having higher scores on energy saving in the home than those with lower education. However, these differences were not statistically significant overall. A potential interaction effect of education on the association between energy saving and gender was tested, suggesting that the relation between education and energy saving was stronger among men than among women. This finding could indicate that education influences the extent to which men engage in energy saving in the home to a larger degree than in women. That is, the gender differences in energy saving in the home were larger among the lower educated, than among the higher educated. While the overall interaction effect was not significant, we detected a significant interaction effect in two of the seven datasets, indicating some uncertainty in this finding. Finally, we identified a clear association between climate concern and more energy saving in the home that was unimpacted by gender or the educational level of the respondents.

The findings in this report corresponds to the core assumption in DIALOGUES that energy consumption is indeed affected by individual characteristics, like gender and education. However, DIALOGUES deliverable D4.1 – State of the energy citizenship data, and the present report suggest that the reuse of openly available data for research questions in energy citizenship is currently limited. Only a few of the DIALOGUES objectives could be examined, and aspects such as the experiences of minorities, energy justice, democratic engagement and participation, and energy identity were largely lacking in the open datasets examined. These shortcomings has also been identified in previous phases of the DIALOGUES project, such as deliverable D2.3 - DIALOGUES: Operational and inclusive energy citizenship. Furthermore, the heterogeneity in survey questions across datasets can be problematic when examining open data. This is because the interpretation of results across studies will be difficult if we are uncertain that the constructs (and survey questions) are understood similarly by those responding to the different surveys.

Nonetheless, reusing open data, and furthering the FAIR and open-data principles, is in many ways, both ethically sound and good research practice. However, to increase the knowledge generation in some specific research areas, there is also a need to be mindful of the data that is created and made available. For instance, developing and using cross-culturally validated scales that have demonstrated that they accurately describe the construct in question, can contribute to larger certainty in the knowledge generation.

To further achieve the goal of obtaining reliable and valid open data generation on topics related to energy citizenship, we suggest efforts should be made to build consensus (in research communities and funding agencies) on which topics and constructs are deemed most important. This way, using (or developing) validated scales can help to achieve a

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shared operationalization of the concept of energy citizenship and its measurement (as also suggested in DIALOGUES D2.3).

Highlighting the associations identified in this report, is important both for the general knowledge production, as well as for policy development. However, given the heterogeneity in survey questions and samples, the results identified in this report should ideally be replicated in studies that are specifically designed to examine these associations.

2 Introduction

To contribute to and support the low-carbon energy transition, the DIALOGUES project develops relevant and necessary knowledge particularly about the roles citizens play in the transition. To fully understand these multiple and diverse roles, DIALOGUES focuses both on the individual as well as the group scale, applying both qualitative and quantitative methods. Addressing complex issues related to individual energy engagement and behavior, generalized knowledge on the group level is useful if we want to understand how it is possible to understand, influence, and facilitate energy citizenship across different social groups.

This report continues the work performed in DIALOGUES deliverable 4.1 State of the energy citizenship data (D4.1) (Standal & Nilsen, 2022), which concluded with three main findings: First, that data availability would be improved by considering and aligning the contents of terms and concepts we use for open data in energy citizenship research. Second, more data is needed to get a deeper understanding of underprivileged groups. Thirdly, identifying what can be assumed to be general traits and which are context-specific when it comes to facilitating energy citizenship, ought to be further investigated.

The present report aimed to demonstrate the feasibility to perform a meta-analysis of the open datasets we searched for, identified, and curated in D4.1. We do so to provide input and answers to DIALOGUES research objectives and questions listed in Table 1. This was performed in order to identify which energy citizenship insights from previous data that could serve as a roadmap for future work within energy citizenship, making future outputs useful to policymakers and stakeholders. Furthermore, we also wanted to highlight in which areas there is insufficient data to perform cross-study analyses. While much of the quantitative research on energy citizenship in social science deals with surveys, investigations, or field tests of a specific energy behaviour for a specific sub-population, this part of the DIALOGUES project aims to draw more generalized statements analysing energy behaviours across a variety of populations.

Thus, building upon D4.1, this report attempts to generate generalizable information on the manifestation of energy citizenship, such as energy-related behaviour, and how it is associated with gender, education, and climate concerns. As such, this task also examines the effects of social characteristics across modes of citizen engagement in energy. The state of the energy citizenship data report (D4.1) addressed issues concerning the actual availability and quality of open data. We debate these issues

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further here, as these challenges are also relevant for the meta-analysis of these existing datasets.

In DIALOGUES, we see energy citizenship research as an opportunity to link the Energy Union's four strategic objectives (decarbonising buildings, renewables uptake, energy storage, and sustainable mobility) with the various contributions of citizens under one conceptual framework. The focus in this framework are broad trends in citizen engagement with energy topics, and how equity and justice are important factors influencing different citizens' opportunities for this engagement. At the core of DIALOGUES' efforts to support a citizen centric energy transition is therefore to develop a better understanding of how energy citizenship is experienced across populations.

There are several concepts that may be interesting to examine broadly. Gender is a social category structurally shaping our societies, and influencing our views, actions, possibilities and opinions, also in the energy transition. For instance, previous research has reported gender differences in energy access, decision-making and energy behavior (Danielsen, 2012; EIGE, 2013; 2016), and in energy-related education (EIGE, 2016). These structural differences are distributed and experienced differently, something we seek to learn more about in the DIALOGUES project to better develop and adapt energy policies and measures to facilitate for citizens' engagement and participation in the energy transition.

Similarly, aspects of socioeconomic status, such as education, may impact individual behavior and engagement with the energy system. Scholars have previously pointed to education as a driver for change as it can influence environmental values (Asilsoy and Oktay, 2018; Sarid and Goldman, 2021), climate concern, and knowledge and acceptance of renewable energy (Bertsch, Hall, Weinhardt & Fichtner, 2016; Stigka et al., 2014). Individual climate concern has also been shown to be an important determinant of a person's willingness to take climate action (Reichl et al., 2021).

To inform our understanding of the concept of energy citizenship, the datasets identified in D4.1 made it possible to perform meta-analyses looking at gender and education differences, and how climate concern influences people's engagement with the energy system in the form of energy saving in the home.

Thus, the aim of the current report was to identify and meta-analyse open data that can be used to provide insight into DIALOGUES core objectives. In this report we examined the associations between gender, education, energy saving behaviour and climate concern. The specific research questions were:

1) What is the association between gender and energy saving in the home?

2) What is the association between education and energy saving in the home?

3) Does education influence the association between gender and energy saving in the home?

4) What is the association between climate concern and energy saving in the home?

5) How does gender and education influence the association between climate concern and energy saving in the home?

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3 Methods

This study is a meta-analysis utilizing individual participant data from openly accessible datasets that are relevant to the energy citizenship research field. Datasets were identified using a systematic search strategy using 51 keywords in 44 search queries and the complete approach can be found in DIALOGUES D4.1 – State of the energy citizenship data report (Standal & Nilsen, 2022).

3.1 Data sources and research question development

DIALOGUES D4.1 (Standal & Nilsen, 2022) yielded a final sample of 44 datasets with potentially relevant individual participant data. These datasets were curated into categories of meta-data and formed the basis for the developing the research questions in the current paper.

The research questions answered in this report were developed in an iterative process. First, the objectives of the DIALOGUES project (see Biresselioglu et al., 2021a) were examined to identify areas where quantitative individual participant data can have the greatest impact for knowledge generation. These objectives were then transformed into research questions that are more aligned with quantitative analysis. The DIALOGUES objectives and subsequent preliminary research questions can be seen in Table 1.

Table 1. DIALOGUES objectives and quantitatively aligned formulations

DIALOGUES objectives	Quantitatively aligned formulations
#1.2 How do individual and community engagements with the energy system emerge and evolve towards active democratic participation?	How is individual engagement with the energy system associated with democratic participation? How is community engagement with the energy system associated with democratic participation?
#1.3 How does engagement with the energy system relate to structural inequalities in terms of gender, class, race ethnicity, migrant status, etc.	How is gender related to energy system engagement? How is socioeconomic status (class) related to energy system engagement?
#3.2 What drives and impedes energy citizenship among specific parts of society that are not yet well represented in the Energy Union, such as women, single parents, the unemployed, recent migrants, the energy poor, etc.?	What is the association between energy citizenship and gender? What is the association between energy citizenship and socioeconomic status (class)?

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#4.1 How can underlying reasons for energy engagement (such as education and gender normative roles) be approached quantitatively?	What are the associations between underlying reasons (e.g., climate beliefs) and energy engagement and how are these influenced by education, socioeconomic status, and gender?
#4.2 What common actions and energy identities characterize the various pathways towards deeper energy citizenship?	What are the associations between energy behaviors (e.g., pro-environmental behavior) and energy citizenship (engagement, participation, etc.)? What are the associations between energy identity and energy citizenship (engagement, participation, etc.)?
#5.3 How can concepts in energy-justice, such as equitable distributions of costs and benefits, perceived fairness and collective efficacy intersect with the deepening of energy citizenship?	What are the associations between equality/equity and energy citizenship? What are the associations between sense of community and energy citizenship?

In the second step, complex concepts such as energy citizenship and engagement with the energy system were reduced to concrete dimensions, based on the literature review in DIALOGUES D2.2 (Biresselioglu et al., 2021b) and on the operational conceptualizations in DIALOGUES D2.3 (Massullo et al., 2022). These dimensions included environmental consciousness, awareness and knowledge, concern and belief of climate change, environmental self-identity, a sense of personal responsibility for environmental outcomes, personal value system, willingness to engage, take climate actions and support climate policies, and the use of- and access to energy in the home.

In the next step, the datasets were carefully examined to identify variables that could be used to answer these research questions or provide data to the dimensions of the complex constructs. For Eurobarometer datasets we investigated datasets categorized under “Energy and natural resources”, and “Environment and conservation”, using the CESSDA Topic Classification (CESSDA, 2023).

Fourth, we systematized the variables in the datasets to examine which research questions we had sufficient data to provide usable insight. Only a few dimensions of the complex constructs mentioned above had sufficient similar data to warrant a meta-analysis. This resulted in energy system engagement being operationalized as energy saving in the home. The final operationalizations of the research questions can be found in Table 2.

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Table 2. DIALOGUES objectives, quantitative formulations and D4.2 research question operationalization

DIALOGUES objective	Quant. formulations	D4.2 Research Question
#1.3 How does engagement with the energy system relate to structural inequalities in terms of gender, class, race ethnicity, migrant status, etc.	How is gender related to energy system engagement?	What is the association between gender and energy saving in the home?
#1.3 How does engagement with the energy system relate to structural inequalities in terms of gender, class, race ethnicity, migrant status, etc.	How is socioeconomic status (class) related to energy system engagement?	What is the association between education and energy saving in the home?
#3.1 What are the specific barriers for women at individual, symbolic and structural levels to engage in energy citizenship actions in their private sphere and in the community? What are promising approaches to overcome these barriers at individual, community and local government levels?	How does socioeconomic status influence the association between gender and energy citizenship?	How does education impact the association between gender and energy saving in the home?
#4.1 How can underlying reasons for energy engagement (such as education and gender normative roles) be approached quantitatively?	What are the associations between underlying reasons (e.g., climate beliefs) and energy engagement and how are these moderated by education and gender?	What is the association between climate concern and energy saving in the home? How do education and gender influence this association?

This yielded ten potential datasets for the research questions in the current paper. Two of the datasets (Eurobarometer 65.3 and Eurobarometer 75.1) were excluded due to having the energy saving question as an optional dichotomized question, and one dataset (Enable.EU - Enable.EU team & Galev, 2019) was excluded due to difficulties in interpreting an ambivalent energy saving question. Thus, after further examination of the

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datasets, we ended up with seven datasets that served as the basis for analysis. Descriptive information of datasets can be found in Table 3.

Table 3. Descriptive information of analysed datasets

Project	Year	Sample characteristics	Sample size	Location	Doi
Public Attitudes and Behaviours Toward the Environment	2007	Nationally representative sample Age 16+	3 618	England	10.5255/UKDA-SN-5741-1
Public attitudes and behaviours towards the environment - tracker survey	2009	Nationally representative sample Age 16+	2 929	England	10.5255/UKDA-SN-6366-1
European Social Survey 8	2016	Random probabilistic sampling. Age 15+	44 387	23 European countries	10.21338/ESS8E02_2
NATCONSUMERS.EU H2020	2017	Nationally representative samples. Age 18-65	4 011	United Kingdom Denmark Italy Hungary	10.5281/zenodo.820364
ECHOES.EU H2020	2018	Nationally representative in age, income and gender. Age 18+	18 037	31 European countries	10.5281/zenodo.3524917
SMARTEES.EU H2020	2020	Convenience sample.	439	Romania	10.5281/zenodo.5617851
Eurobarometer 97.5	2022	Probability stratified. Age 15+	37 223	39 European countries	10.4232/1.14010

Note: Sample size describe the complete sample size of the dataset, and not necessarily number of respondents for the survey questions relevant for this report. For sample size on the included questions, see Table 4 below. Full references can be found in the reference list.

3.2 Variables and data management

In pooling the data, variables that were retained from the study-specific databases were gender, education, questions on energy saving, and climate concern. Nationality was also collected for descriptive purposes.

Gender was dichotomized as male or female. Some datasets also had other options such as ‘other’, or ‘prefer not to say’. However, these datasets were few and the options

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varied, so as they are not comparable across datasets these categories were set to missing for statistical purposes. Education was dichotomized as higher (having completed a university degree of minimum three years) or lower. Energy saving in the home was collected on continuous scales with length of 3-7 points. Similarly, climate concern was collected on continuous scales with length of 4-7 points. The survey questions, original ranges and dataset of origin for these two constructs can be found in Appendix A and B.

While many of the datasets have questions on similar topics, few (or none) word the questions in the same way, or use the same scales. Thus, all continuous questions were linearly transformed to have the same scale. Both energy saving in the home and climate concern were transformed into seven-point scales (0-6).

3.3 Analysis

Individual participant data (IPD) at the dataset level was used to produce effect estimates between specified variables for the combined sample. IPD allows greater scope and flexibility in the analyses when compared to ordinary meta-analyses. This includes the ability to harmonize dataset-level analyses and to add covariates (Debray et al 2015a, Debray et al 2015b). IPD can also provide in depth explorations and analyses that differ from the research questions in the original papers or research reports (e.g., looking at gender differences as an outcome rather than a covariate).

IPD meta-analyses can be performed in two ways, a one-stage approach or a two-stage approach. In the one-stage approach the participant level data is analyzed in a single step model that accounts for clustering of patients within studies. In the two-stage approach, the IPD from each study are analyzed separately, and then combined into an overall effect (Burke et al., 2017). The two-stage approach is often preferred as it uses standard meta-analysis methods that are more widely known (Burke et al., 2017; Stewart et al., 2012). In the present study, the analysis was performed using the ipdmetan package in Stata 17 (Fischer, 2015; 2022; StataCorp, 2021). The ipdmetan package utilizes a two-stage individual participant data meta-analysis using the inverse-variance method to arrive at an overall effect size for the pooled sample.

In the first stage, ipdmetan fits a specified model to the data one dataset at the time. In the second stage these are combined into a traditional meta-analysis model. We assume that the effect size vary from study to study due to heterogeneity between studies (e.g., sampling and demographic differences, survey differences), and a random effects model was used (Dettori et al., 2022).

First stage analysis models

To investigate statistical differences between men and women, and between higher and lower education, logistic regression was used. Thus, for the first two research questions, bivariate logistic regression was used to investigate the gender and educational level

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differences in energy saving for each dataset. By using gender or education as a dependent variable in a logistic regression we are in this case not examining causes between the independent and dependent variable. The analysis is used to highlight differences between the binary outcome variable groups (e.g., genders) for the independent variable (e.g., energy saving). For instance, in RQ1 we estimated how the likelihood of a person being female rather than male, varied by energy saving score. An odds ratio greater than one means that there is a higher likelihood that the person is female rather than male when energy saving increases, while an odds ratio lower than one would mean a lower likelihood of being female than male. Similarly for education, an odds ratio greater than one would mean a higher likelihood of the person having higher education compared to lower education, while an odds ratio lower than one would mean a lower likelihood of having higher education. Statistically significant results on the logistic regression would mean that a significant difference in the independent variable was identified between the two groups in the outcome variable for each analysis (i.e., gender differences (RQ1), or differences in educational level (RQ2)). For the third research question, gender was used as the dependent variable, and education and energy saving as the independent variables in order to examine whether any potential differences between genders still hold also after controlling for educational level. Furthermore, the interaction between gender and education was investigated in order to determine whether the association between gender and energy saving depends on the educational level of the individual.

Linear regression with energy saving as the dependent variable, and climate concern as the independent variable was used to investigate the association between these variables in research question four. To answer research question five, we also added education and gender as independent variables, to see whether the association still holds after controlling for these variables.

IPD meta-analysis provides an overall mean estimate pooled across datasets. A significance level of $\alpha = 0.05$ and 95% confidence intervals (CI) were used throughout.

4 Results

Sample description

The total sample consisted of 110 548 individuals, of which 57 251 were female (51.79%) and 53 297 were male (48.21%). Of those who had information on education, 33 345 (68.85%) described having completed higher education, while 73 698 (31.15%) had lower education. Regarding energy reduction, on the standardized seven-point scale (0-6), the sample mean was 3.77 (Standard Deviation (SD) ± 1.72), with a slight skew towards higher values. Climate concern had a sample mean of 3.54 (SD ± 1.63).

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Table 4. Sample descriptive information

Variable	Sample characteristics
Gender (*n* = 110 548) – *n* female (%)	57 251 (51.79%)
Education (*n* = 107 043) – *n* higher (%)	33 345 (31.15%)
Nationality (*n* = 110 644)	
- Albania	1 017 (0.92%)
- Austria	3 544 (3.20%)
- Belgium	3 369 (3.04%)
- Bosnia and Herzegovina	1 011 (0.91%)
- Bulgaria	1 651 (1.49%)
- Croatia	1 611 (1.46%)
- Cyprus	1 240 (1.12%)
- Czechia	3 891 (3.52%)
- Denmark	2 607 (2.36%)
- Estonia	3 572 (3.23%)
- Finland	3 580 (3.24%)
- France	3 762 (3.40%)
- Germany	5 029 (4.55%)
- Greece	1 622 (1.47%)
- Hungary	4 271 (3.86%)
- Iceland	1 383 (1.25%)
- Ireland	4 279 (3.87%)
- Israel	2 557 (2.31%)
- Italy	5 316 (4.80%)
- Kosovo	1 059 (0.96%)
- Latvia	1 567 (1.42%)
- Lithuania	3 723 (3.36%)
- Luxembourg	996 (0.90%)
- Malta	754 (0.68%)
- Montenegro	507 (0.46%)
- Netherlands	3 285 (2.97%)
- North Macedonia	1 041 (0.94%)
- Norway	3 131 (2.83%)
- Poland	3 365 (3.04%)
- Portugal	2 881 (2.60%)
- Romania	2 112 (1.91%)
- Russia	2 566 (2.32%)
- Serbia	1 048 (0.95%)
- Slovakia	1 622 (1.47%)
- Slovenia	2 887 (2.61%)
- Spain	3 544 (3.20%)
- Sweden	3 122 (2.82%)
- Switzerland	2 572 (2.32%)
- Turkey	1 600 (1.45%)
- United Kingdom	11 165 (10.09%)
- Other	785 (0.72%)
Energy saving (0-6) (*n* = 108 739)	3.77 (1.72)
Climate concern (0-6) (*n* = 71 487)	3.54 (1.63)

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Notes: Values given are counts (%) for categorical variables and mean (SD) for continuous variables. Other nationality contains countries with less than 50 individuals, and unspecified answers (e.g., 'other EU').

Meta-analysis results

First, we investigated the association between gender and energy saving (RQ1 – Figure 1). The meta-analysis shows that there is a significant gender difference in energy saving in the home. Women are overall more likely to score higher on energy saving questions. This is largely consistent through time and datasets.

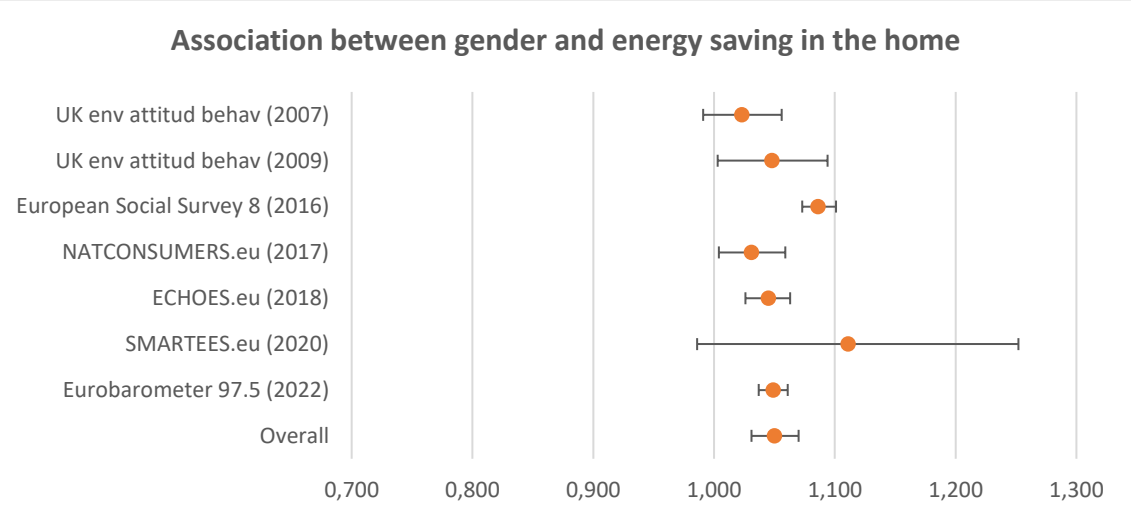

Figure 1 – Associations between gender and energy saving in the home. Note: X-axis shows odds ratio between the groups men and women (female gender = 1) and whiskers 95% confidence interval. Odds ratio > 1 means higher likelihood of being female.

Table 5. Meta-analysis of the association between gender and energy saving in the home

Dataset	Sample size (*n*)	OR (95% CI)	Weight
UK env attitude behav (2007)	3 577	1.023 (0.991-1.056)	13.47%
UK env attitude behav (2009)	2 918	1.048 (1.003-1.094)*	10.18%
ESS 8 (2016)	43 830	1.086 (1.073-1.101)*	20.01%
NATCONSUMERS.eu (2017)	3 742	1.031 (1.004-1.059)*	15.23%
ECHOES.eu (2018)	18 029	1.045 (1.026-1.063)*	18.48%
SMARTEES.eu (2020)	388	1.111 (0.986-1.252)	2.24%
Eurobarometer 97.5 (2022)	36 165	1.049 (1.037-1.061)*	20.38%
Overall	**108 649**	**1.050 (1.031-1.070)***	**100%**

*Note: ESS8: European Social Survey 8. Odds ratio (OR) shows the increase in odds of a responder being female for a single point increase in energy saving in the home. * indicates statistically significant differences between the two groups female and male.*

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Answering the second research question (RQ2 – Figure 2), we investigated the association between education and energy saving in the home. Here we find an overall trend towards higher education favouring more energy saving behaviour, especially for the larger datasets. However, the differences between higher and lower education were not as pronounced and the overall differences are not statistically significant.

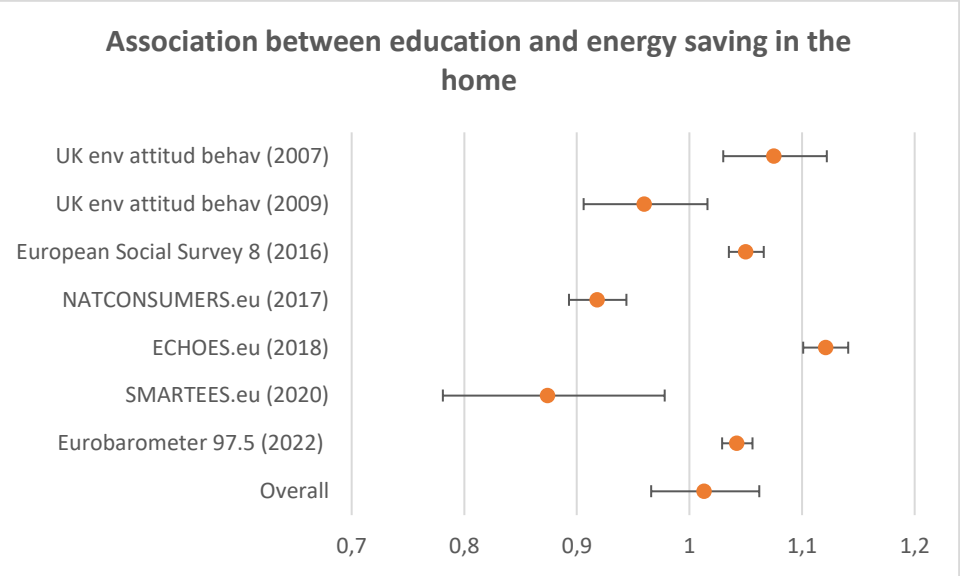

Figure 2 – Associations between education and energy saving in the home. Note: X-axis shows odds ratio between the groups lower and higher educated (higher education = 1) and whiskers 95% confidence interval. Odds ratio > 1 means higher likelihood of having higher education.

Table 6. Meta-analysis of the association between education and energy saving in the home

Dataset	Sample size (*n*)	OR (95% CI)	Weight
UK env attitude behav (2007)	2 521	1.075 (1.030-1.122)*	14.46%
UK env attitude behav (2009)	2 072	0.960 (0.906-1.016)	13.23%
ESS8 (2016)	43 634	1.050 (1.035-1.066)*	16.10%
NATCONSUMERS.eu (2017)	3 742	0.918 (0.893-0.944)*	15.50%
ECHOES.eu (2018)	17 670	1.121 (1.101-1.141)*	15.98%
SMARTEES.eu (2020)	439	0.874 (0.781-0.978)*	8.56%
Eurobarometer 97.5 (2022)	35 093	1.042 (1.029-1.056)*	16.16%
Overall	**105 171**	**1.013 (0.966-1.062)**	**100%**

*Note: ESS8: European Social Survey 8. Odds ratio (OR) shows the increase in odds of a responder having higher education for a single point increase in energy saving in the home. * indicates statistically significant differences between the two groups lower and higher education.*

Third, we investigated the association between gender and energy saving, controlling for education (RQ3 – Figure 3). We see that the gender difference between the groups is

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even more pronounced when controlling for education. This means that women are more likely to engage in energy saving behavior in the home than men at the same educational level.

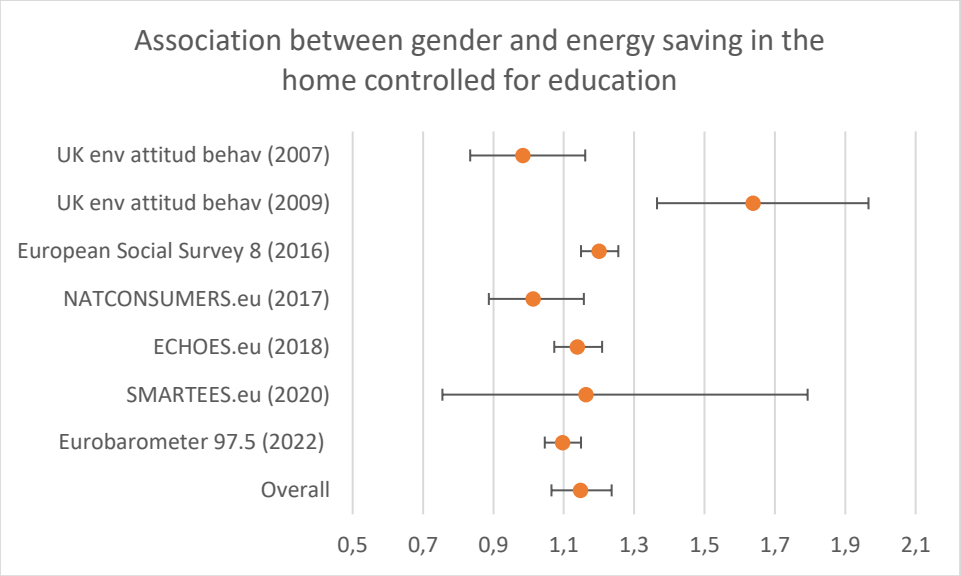

Figure 3 – Association between gender and energy saving in the home, controlled for education. Note: X-axis shows odds ratio and whiskers 95% confidence interval (female gender = 1). Odds ratio > 1 means higher likelihood of being female.

Table 7. Meta-analysis of the association between gender and energy saving in the home controlled for education

Dataset	Sample size (*n*)	OR (95% CI)	Weight
UK env attitude behav (2007)	2 521	0.984 (0.834-1.161)	10.83%
UK env attitude behav (2009)	2 072	1.638 (1.365-1.966)*	9.69%
ESS8 (2016)	43 629	1.201 (1.149-1.255)*	21.65%
NATCONSUMERS.eu (2017)	3 742	1.013 (0.887-1.157)	13.30%
ECHOES.eu (2018)	17 663	1.139 (1.073-1.209)*	20.38%
SMARTEES.eu (2020)	388	1.163 (0.755-1.793)	2.62%
Eurobarometer 97.5 (2022)	35 068	1.097 (1.046-1.149)*	21.44%
Overall	**105 083**	**1.148 (1.065-1.236)***	**100%**

*Note: ESS8: European Social Survey 8. Odds ratio (OR) shows the increase in odds of a responder being female for a single point increase in energy saving in the home. * indicates statistically significant differences between the two genders when controlling for education.*

We also investigated the potential interaction effect of education on the association between energy saving and gender (RQ3 – Figure 4). This analysis was performed to see whether the association between gender and energy saving was dependent on the level of education of the individual. Investigating this difference, we see that the overall interaction effect is just above the significance threshold. This means that the level of

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education did not statically significantly influence energy saving behavior between the genders.

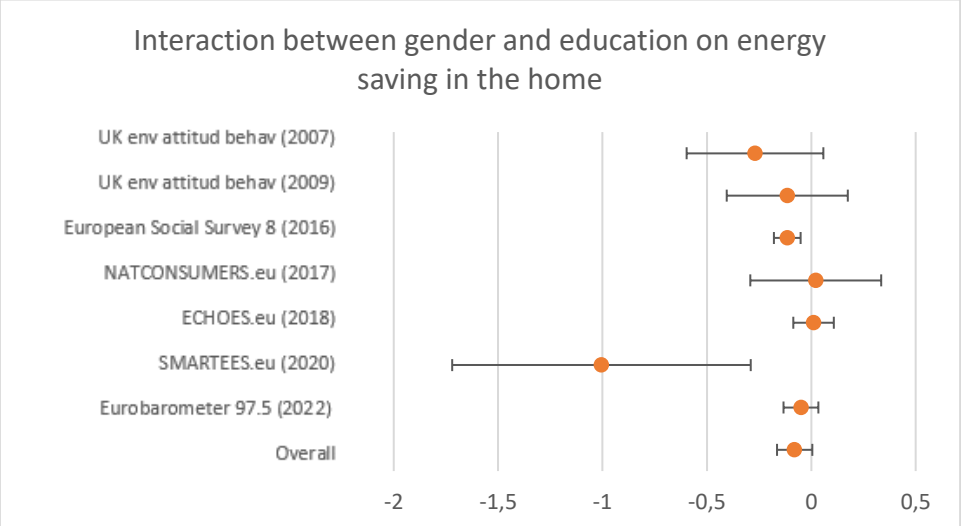

Figure 4 – Interaction effect of gender and education on energy saving in the home. Note: X-axis shows effect size and whiskers 95% confidence interval of the interaction effect between gender and education on energy saving in the home.

Table 8. Meta-analysis of the interaction effect of gender and education on energy saving in the home

Dataset	Sample size (*n*)	Effect size	Weight
UK env attitude behav (2007)	2 521	-0.269 (-0.597 / 0.058)	5.61%
UK env attitude behav (2009)	2 072	-0.115 (-0.405 / 0.175)	6.85%
ESS8 (2016)	43 629	-0.115 (-0.179 / -0.051)*	29.53%
NATCONSUMERS.eu (2017)	3 742	0.022 (-0.292 / 0.335)	6.04%
ECHOES.eu (2018)	17 663	0.011 (-0.086 / 0.108)	24.20%
SMARTEES.eu (2020)	388	-1.005 (-1.720 / -0.290)*	1.35%
Eurobarometer 97.5 (2022)	35 068	-0.049 (-0.133 / 0.034)	26.43%
Overall	**105 083**	**-0.08 (-0.164 / 0.005)**	**100%**

*Note: ESS8: European Social Survey 8. Effect size shows the additional increase of the effect of education between the two genders on energy saving in the home. * indicates a statistically significant interaction effect of education on the association between gender and energy saving. Effect size > 0 indicates a positive interaction effect.*

However, looking at the results beyond the pre-determined statistical threshold, we can see that there is a tendency that education is more important for men than women with regards to more energy saving in the home. Looking at the European Social Survey 8 where the interaction is statistically significant, we can illustrate this trend more clearly (Figure 5).

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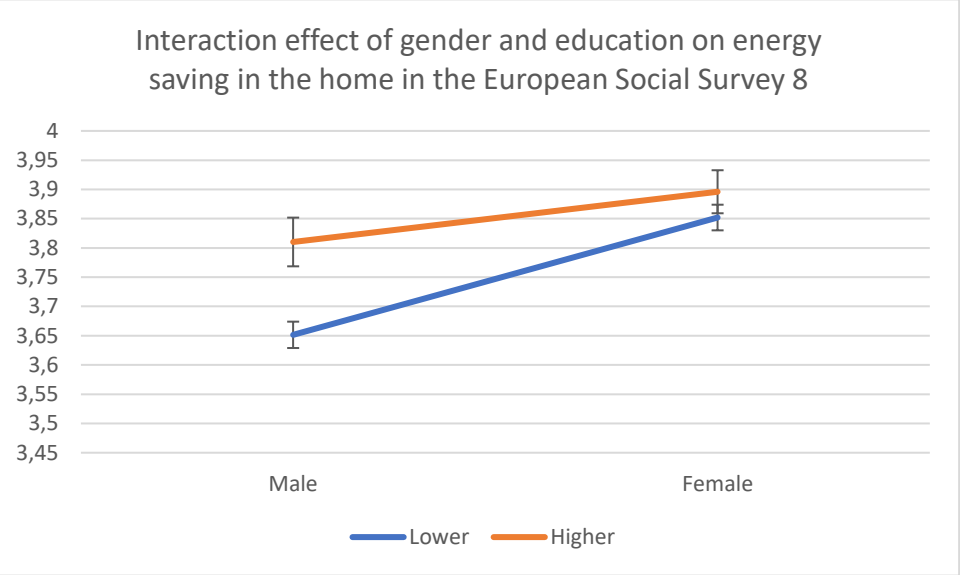

Figure 5 - Interaction effect of gender and education on energy saving in the home in the European Social Survey 8 dataset. Note: Mean energy saving for women and men of higher and lower education in the European Social Survey 8.

Finally, we investigated the association between climate concern and energy saving in the home. Here we see a clear statistically significant positive association between higher climate concern and more energy saving (Figure 6 - RQ4).

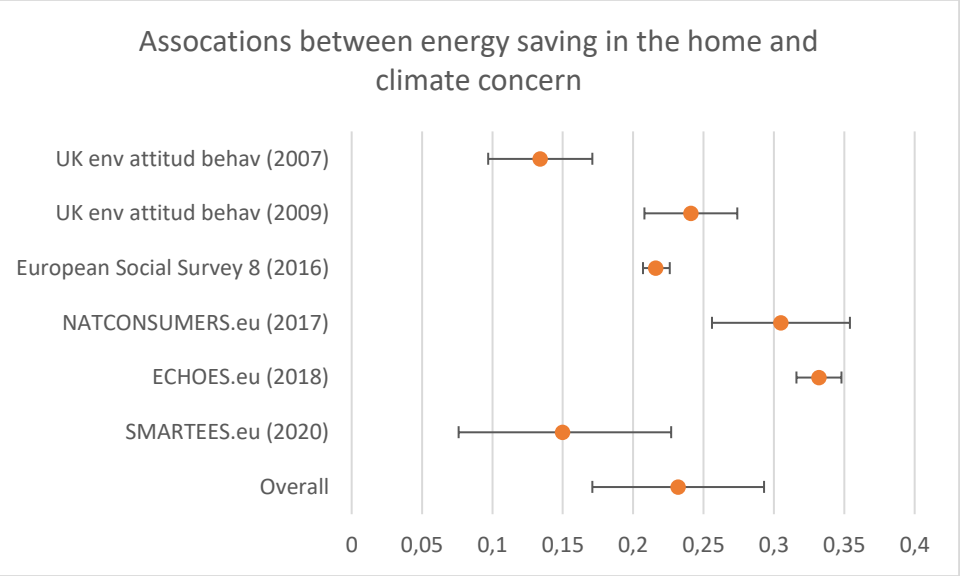

Figure 6 – Associations between energy saving in the home and climate concern. Note: X-axis shows effect size and whiskers 95% confidence interval of the association between climate concern and energy saving in the home. Effect size > 0 indicates a positive association between energy saving and climate concern.

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Table 9. Meta-analysis of the association between energy saving in the home and climate concern

Dataset	Sample size (*n*)	Effect size	Weight
UK env attitude behav (2007)	3 479	0.134 (0.097-0.171)*	16.89%
UK env attitude behav (2009)	2 827	0.241 (0.208-0.274)*	17.12%
ESS8 (2016)	42 224	0.216 (0.207-0.226)*	17.92%
NATCONSUMERS.eu (2017)	3 742	0.305 (0.256-0.354)*	16.16%
ECHOES.eu (2018)	18 037	0.332 (0.316-0.348)*	17.78%
SMARTEES.eu (2020)	438	0.150 (0.076-0.227)*	14.12%
Overall	**70 747**	**0.232 (0.171-0.293)***	**100%**

*Note: Effect size shows the increase in energy saving for a single point increase in climate concern. * indicates a statistically significant association between climate concern and energy saving in the home. Effect size > 0 indicates a positive association between energy saving and climate concern.*

When controlling for gender and education (RQ5), the above association is largely unchanged (Figure 7).

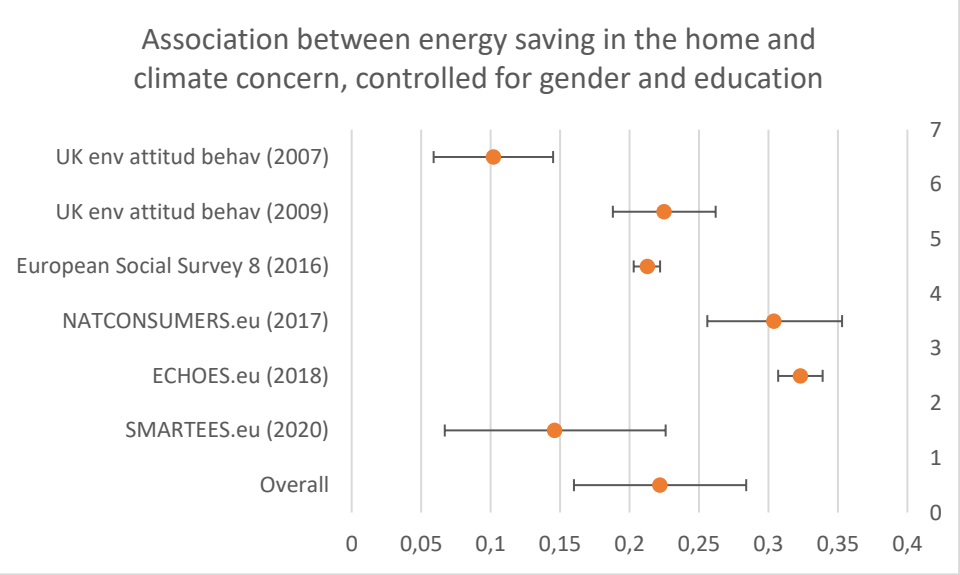

Figure 7 – Associations between energy saving in the home and climate concern, controlled for gender and education. Note: X-axis shows effect size and whiskers 95% confidence interval of the association between climate concern and energy saving in the home when controlling for gender and education. Effect size > 0 indicates a positive association between energy saving and climate concern.

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Table 10. Meta-analysis of the association between energy saving in the home and climate concern, controlled for gender and education

Dataset	Sample size (*n*)	Effect size	Weight
UK env attitude behav (2007)	2 468	0.102 (0.059-0.145)*	16.67%
UK env attitude behav (2009)	2 032	0.225 (0.188-0.262)*	17.03%
ESS8 (2016)	42 034	0.213 (0.203-0.222)*	18.07%
NATCONSUMERS.eu (2017)	3 742	0.304 (0.256-0.353)*	16.33%
ECHOES.eu (2018)	17 663	0.323 (0.307-0.339)*	17.93%
SMARTEES.eu (2020)	387	0.146 (0.067-0.226)*	13.97%
Overall	**68 326**	**0.222 (0.160-0.284)***	**100%**

*Note: Effect size shows the increase in energy saving for a single point increase in climate concern, while controlling for education and gender. * indicates a statistically significant association between climate concern and energy saving in the home when controlling for education and gender. Effect size > 0 indicates a positive association between energy saving and climate concern.*

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5 Discussion

The aim of this report was to provide input to five research questions related to the core objectives of the DIALOGUES EU project. Through a process of operationalizing the objectives into research questions, and by curating relevant survey questions in open datasets, seven datasets were ultimately used to investigate the associations between gender, education, energy saving and climate concern.

The results of the meta-analysis indicate three main findings. First, we found a positive association between female gender and energy saving in the home. Second, we found a positive association between climate concern and energy saving in the home. And third we identified a potential interaction between gender and education where differences in higher and lower education was more impactful on energy saving in the home for men than for women.

5.1 Discussion of results

The meta-analysis across the different data sets identifies a gender difference in *energy saving in the home*. This difference articulates in a way where the more concerned a respondent is with energy saving in the home, the more likely the respondent is a woman. We consider this a highly interesting finding, supporting arguments that energy research should better integrate gender issues in general (Sovacool 2014; Ryan 2014; Mechlenborg & Gram-Hanssen 2020) as well as particular sub-areas like domestic energy savings and consumption (Bartiaux 2022).

Gender difference regarding energy saving in the home has several potential explanations. Previous research has pointed to aspects related to the double and triple burden, in which women in many societies to a larger degree are responsible for household tasks and household energy (Röhr, 2007). Other explanations relate to gender differences regarding concern for climate change (Knight (2019)), as reason for different efforts in reducing their own energy use and carbon footprint. As women's income is lower, energy saving might also express economic concerns, and can be linked also to various forms of energy poverty (Feenstra and Clancy 2020). Gender differences in this kind of behaviour can also be related to other inequalities, due to exclusion from the economy through care-work, domestic responsibilities, lack of protection, and health impacts (Robinson, 2019).

Our results also show that there is a tendency for those with higher education to engage in energy saving behaviour (Mills & Schleich, 2012). This could be due to education involving exposure to perspectives in social and academic spheres that might promote mindset transformation towards sustainability (Žalėnienė & Pereira, 2021). However, we see that this tendency is not statistically significant across datasets, so the differences may be less certain, or they might be too small to have much practical significance. Education is associated with income, and thus those with lower income may also have an incentive to save energy as a cost-saving measure. Higher education might therefore influence energy consumption both ways, increase saving due to increased knowledge,

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or increase consumption due to higher income (Inglesi-Lotz & Morales 2017). However, there may exist confounders that influence both the propensity to undertake higher education and the willingness to save energy in the home. This could mean that the association between education and energy saving would be explained by these confounders rather than by a direct link between these two factors.

The interaction between gender, education and energy saving reveals that the primary difference between genders may be in the lower education group, where men score lower than women on energy saving. Among the higher educated the gender differences are not as pronounced. The overall interaction effect was not statistically significant, however. Nonetheless, this is an interesting finding that needs to be explored further, both quantitatively and qualitatively, to build more evidence, and to explain the potential mechanisms behind the phenomenon.

Perhaps unsurprisingly, we also find a significant association between climate concern and energy saving in the home. This could mean that energy saving is not only financially motivated, but also due to willingness to contribute to a sustainable energy transition. This is also supported in research finding correlations between reduced energy consumption and the perception of personal responsibility for climate change mitigation (Boto-García & Bucciol 2020).

These findings respond to the core assumption in DIALOGUES that energy consumption is indeed affected by individual characteristics, like gender and education. This is important both for the general knowledge production, as well as for policy development. However, given the heterogeneity in survey questions and samples, the results identified in this report should ideally be replicated in studies that are designed to examine these associations. Thus, not only relying on secondary data analysis. In addition, to get a more in depth understanding of why gender – and other differences occur and seems to be maintained, DIALOGUES qualitative approaches in the CALs will provide relevant data and knowledge.

5.2 Discussion of data

The DIALOGUES research objectives aim to examine a broad range of topics that relate to energy citizenship. For instance, the role social identity, democratic participation, individual engagement and behaviour in the energy transition and energy citizenship. How these constructs are impacting each other can also vary depending on which subgroup is examined (e.g., socioeconomic status, gender, race/ethnicity, employment status) as well as the intersections of these categories.

In the DIALOGUES project these aspects are approached qualitatively in interviews and a range of methodological approaches in the citizen action labs. In addition, they will be investigated quantitatively through a dedicated forthcoming DIALOGUES survey. DIALOGUES deliverable D4.1 – State of the energy citizenship data report (Standal & Nilsen, 2022), and the present report demonstrate that the possibility to reuse open available data to examine many of these complex topics in energy citizenship is currently limited. Only a few of the DIALOGUES objectives could be operationalized in a way that corresponded well to the data available. Subgroups such as minorities and

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underprivileged, highly relevant aspects like energy justice, democratic energy engagement and participation, and energy identity were largely lacking in the open datasets examined.

Furthermore, for those research questions that were analysed in this report, the survey questions in the selected datasets naturally varied in scale, range, and question wording. Datasets also vary across time, nationality, sample size, and sampling strategy. In this study, we followed our original analysis plan, but the heterogeneity in data begs the question of whether there is greater value in interpreting each dataset result separately, rather than attempting a meta-analysis on such varied data. A lot of the data in this and other research fields are open primarily due to new open research policies that have become more prevalent in the last years. While this primarily represents a democratic and positive development in making data and research accessible to more people and places, it still needs a bit of streamlining and more structure on how we collect and make data available. The current situation requires caution when re-using of these data for aggregate results.

Thus, this report shows that while we can detect some correlations and dependencies, generalizable and robust answers to the DIALOGUES research questions may still be a way off. The current study managed to operationalize a small dimension of energy engagement, using survey questions that may or may not realistically answer the same underlying construct. The heterogeneity in survey questions and ranges is however problematic for meta-analyses of open data. This is because the interpretation of results across studies, whether or not they are meta-analyses, will be difficult if we are uncertain that the constructs (and survey questions) are understood in the same way across these samples. For example., owning an electric car may be associated with pride. But the causes of pride in a lower-income country could be associated with the wealth needed to buy such a car, while in a higher-income country it may be more impacted by social norms.

Similarly, how gender is constructed is a longstanding debate, and as one outcome, surveys have now started included more options than represented by the dichotomy male/female. Some of the datasets included in this study, included categories such as “other” or “prefer not to say” to present an option for people not identifying as male or female. However, the low frequency of the inclusion of these categories and the wording when included varied too much to be useful in the present analysis.

Nonetheless, the open science movement and FAIR principles (Wilkinson et al., 2016) are laudable and should be supported. Reusing open data and furthering the FAIR and open-data principles, is in many ways both ethically sound and good research practice. If the goal is to move towards larger certainty (through a corpus of knowledge) in some specific research areas, there is also a need to be mindful of the data that is created and made available. If every survey has their own version of a construct, combining these data will be difficult at best, and provide incorrect results at worst. Optimally, we should be identifying, validating and using cross-culturally scales that have demonstrated that they accurately describe the construct in question. Thus, for most of the topics and subgroups mentioned in the DIALOGUES objectives, the data is not yet sufficient to warrant cross-study analyses.

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We realize that the primary aim of each single study is not to make the data harmonize with other studies. However, collaboration and consensus building (in research communities and funding agencies) on which topics and constructs are deemed most important will contribute to data that are open, trustworthy, and useful for cross-study comparisons. To further energy citizenship research, we advocate for efforts to facilitate consensus for (or develop) validated scales that can help provide insight into topics relevant for the DIALOGUES objectives.

5.3 Strengths and limitations

The use of individual participant data is a particular strength of the current study. IPD of open data allows us to investigate associations across contexts using a large sample. The original data collection for these datasets has purposes that may differ from those that are enabled by secondary analysis of open datasets. For instance, data on gender may be collected and analyzed as a control variable for the original research question, while different analyses of the gender data, e.g., as a predictor for energy behavior, may yield novel and interesting results.

Datasets used in this report consisted to a large degree of large surveys using sampling strategies that increase the likelihood of achieving broad, nationally representative samples. Thus, the associations identified in the present report should be robust, if we assume that the constructs investigated are adequately similar across studies. The current study performed exploratory analyses of datasets with large heterogeneity, and thus represent an excellent indicator for topics that could be further investigated in separate studies, specifically designed to investigate or explain the associations suggested in this paper.

Limitations to this study is to a large degree described in the data discussion section above. Heterogeneity of the datasets and survey questions could influence the validity of the associations identified in the meta-analyses. Furthermore, although the meta-analysis builds upon a systematic search of open data, it is possible that there are other open datasets that could be included that would be relevant for the specific research questions, and for the DIALOGUES core objectives where data was insufficient in the present study.

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6 Conclusion

The aim of this report is to investigate the potential for the re-use of existing open datasets to answer DIALOGUES core objectives. Building upon a search of open datasets five research questions looking at gender, education, and climate concern in relation to energy saving in the home, were answered using individual participant data meta-analyses. Across large samples, gender differences in energy saving in the home was identified. Furthermore, this gender difference may depend on the level of education, where lower educated men report less energy saving in the home than lower educated women, while gender differences are much smaller for the higher educated. The mechanisms behind these differences should be investigated in further studies that are specifically designed to explore and identify the causes and explanations for this finding.

The present study also highlights the inadequacies of using existing open data to investigate research questions that are not the focus of the single datasets, as well as the scarcity of standardized, comparable and comprehensive datasets on energy citizenship at the European level. Thus, to further the development of energy citizenship research we advocate for efforts to be made to facilitate consensus on which key constructs ought to be investigated further to develop cross-culturally validated scales can improve and broaden our knowledge of these topics and dependencies. This way, the energy citizenship research area can build a robust corpus of knowledge over time and across subgroups and cultures.

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8 Appendix

8.1 List of Tables

8.2 List of Figures

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and whiskers 95% confidence interval. Odds ratio > 1 means higher likelihood of having higher education.

Figure 3 – Association between gender and energy saving in the home, controlled for education. Note: X-axis shows odds ratio and whiskers 95% confidence interval (female gender = 1). Odds ratio > 1 means higher likelihood of being female.

Figure 4 – Interaction effect of gender and education on energy saving in the home. Note: X-axis shows effect size and whiskers 95% confidence interval of the interaction effect between gender and education on energy saving in the home.

Figure 5 - Interaction effect of gender and education on energy saving in the home in the European Social Survey 8 dataset. Note: Mean energy saving for women and men of higher and lower education in the European Social Survey 8.

Figure 6 – Associations between energy saving in the home and climate concern. Note: X-axis shows effect size and whiskers 95% confidence interval of the association between climate concern and energy saving in the home. Effect size > 0 indicates a positive association between energy saving and climate concern.

Figure 7 – Associations between energy saving in the home and climate concern, controlled for gender and education. Note: X-axis shows effect size and whiskers 95% confidence interval of the association between climate concern and energy saving in the home when controlling for gender and education. Effect size > 0 indicates a positive association between energy saving and climate concern.

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8.3 Appendix

Appendix A – Operationalized concept: Energy saving in the home

Concept	Dataset	Survey question	Survey answer (value)
Engagement with the energy system – energy saving in the home	Public Attitudes and Behaviours Toward the Environment	"… please tell me which answer on the card applies to you personally at the moment. There are no right or wrong answers – we're just interested in what you do at the moment …" **Cut down on the use of gas and electricity at home**	I don't really want to do this (0) I haven't really thought about doing this (1) I've thought about doing this, but probably won't do it (2) I'm thinking about doing this (3) I've tried doing this, but I've given up (4) I'm already doing this, but I probably won't manage to keep it up (5) I'm already doing this and intend to keep it up. (6)
	Public attitudes and behaviours towards the environment - tracker survey	How much do you agree or disagree with these statements? **I don't really give much thought to saving energy in my home**	Strongly agree (0) Tend to agree (1) Neither agree nor disagree (2) Tend to disagree (3) Strongly disagree (4)
	European Social Survey 8	There are some things that can be done to reduce energy use, such as switching off appliances that are not being used, walking for short journeys, or only	Never (0) Hardly ever (1) Sometimes (2) Often (3) Very often (4)

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		using the heating or air conditioning when really needed. In your daily life, how often do you do things to reduce your energy use?	
	NATCONSUMERS.EU H2020	Have you tried any of the following ways to save energy? Reducing the heating temperature in the living room or in bedrooms	No, I don't do this (0) Yes, sometimes I do it (1) Yes, I do it regularly (2)
	ECHOES.EU H2020	I intend to decrease my energy consumption for heating and cooling my dwelling.	Strongly disagree (0) Moderately disagree (1) Neither disagree nor agree (2) Moderately agree (3) Strongly agree (4)
	SMARTEES.EU H2020	In your daily life, how often do you do the following things? [Switch off heating unless I really need it]	Never (0) Hardly ever (1) Sometimes (2) Often (3) Very often (4) Always (5)
	Eurobarometer 97.5	Please tell to what extent you agree or disagree with each of the following statements. I have recently taken action to reduce my own energy consumption or I plan to do so in the near future	Totally disagree (0) Tend to disagree (1) Tend to agree (2) Totally agree (3)

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Appendix B – Operationalized concept: Climate concern

Concept	Dataset	Survey question	Survey answer (numerical value)
Underlying reasons for engagement – climate concern	Public Attitudes and Behaviours Toward the Environment	How much do you agree or disagree with this statement? The so-called 'environmental crisis' facing humanity has been greatly exaggerated	Strongly agree (0) Tend to agree (1) Neither agree nor disagree (2) Tend to disagree (3) Strongly disagree (4)
	Public attitudes and behaviours towards the environment - tracker survey	How much do you agree or disagree with these statements? The so-called 'environmental crisis' facing humanity has been greatly exaggerated	Strongly agree (0) Tend to agree (1) Neither agree nor disagree (2) Tend to disagree (3) Strongly disagree (4)
	European Social Survey 8	How worried are you about climate change?	Not at all worried (0) Not ver worried (1) Somewhat worried (2) Very worried (3) Extremely worried (4)
	NATCONSUMERS.EU H2020	To what extent do you agree or disagree with the following statements? I am concerned about climate change, and always try to reduce my carbon	Strongly disagree (0) Somewhat disagree (1) Neither agree nor disagree (2) Somewhat agree (3) Strongly Agree (4)

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		emissions in day-to-day life	
	ECHOES.EU H2020	Most scientists say that the world's temperature has slowly been rising over the past 100 years. Do you think this has been happening?	No, definitely not (0) Probably not (1) Maybe, I don't know (2) Probably (3) Yes, definitely (4)
	SMARTEES.EU H2020	How concerned [Climate change]	Not at all concerned (0) Not very concerned (1) Somewhat unconcerned (2) Neither concerned nor unconcerned (3) Somewhat concerned (4) Concerned (5) Extremely concerned (6)

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