Energy for Sustainable Development 68 (2022) 170–181

Contents lists available at ScienceDirect

Energy for Sustainable Development

Energy saving behaviours of middle class households in Ghana, Peru and the Philippines

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ARTICLE INFO

Article history:
Received 15 July 2021
Revised 3 February 2022
Accepted 12 March 2022
Available online 5 April 2022

Keywords:
Energy efficiency
Curtailment
Consumer behaviour
Energy saving
Developing countries

ABSTRACT

Demand-side management of energy seeks to foster energy efficiency investments and curtailment behaviour in households. The role of environmental concern and knowledge for both types of energy saving behaviour has hardly been investigated in middle income countries with growing middle classes and rising electricity demand. Drawing on unique household survey data from Ghana, Peru and the Philippines, this paper analyses the links from individual motivation to behaviour, and from behaviour to the impact on households' total electricity expenditures. We find that consumers with more environmental concern are more likely to adopt curtailment behaviours, but that concern does not influence energy efficiency investments. In turn, higher levels of environmental knowledge make households' energy efficiency investments more likely, but do not influence curtailment. Neither energy efficiency investments nor curtailment behaviours significantly impact households' electricity expenditures. Small differences between Ghana, Peru and the Philippines exist.

Introduction

In middle-income countries, economic development and growing middle classes who can afford more appliances and electricity consumption put energy systems under pressure. The share of residential electricity consumption in total energy use in these countries is steadily increasing. In the Philippines, for example, the electricity demand in the residential sector increased by 5.8% annually between 1982 and 2015, whereas the demand in the industry sector only increased by 3.3% in the same time period (IEA, 2020b; Santos, 2021). Rising incomes and a rising demand for digitally connected devices and air-conditioning are projected to be responsible for a major push in electricity demand until 2040 (IEA, 2020a). The surge in ownership of major household appliances such as air-conditioners in emerging markets and developing countries alone is projected to drive over 80% of the 700TWh increase in global residential electricity demand until 2025 (IEA, 2020a: 218). The energy transition in middle income countries such as Ghana, Peru and the Philippines therefore needs to focus on strategies to increase energy efficiency as well as to save energy. Understanding current energy behaviours of the growing middle classes is imperative to improve the targeting of current and future energy programmes.

Energy saving behaviours can be differentiated into purchasing behaviours and repetitive energy saving behaviours. Purchasing behaviours of individuals include investments in retrofitting homes for energy efficiency and in energy efficient appliances and other products (Karlin et al., 2014; Schleich, 2019). Repetitive energy saving behaviours in the home are also called curtailment behaviours: they capture the habitual, low-effort behaviours in the household such as switching off lights or turning off appliances that are not in use (Black et al., 1985). Many existing studies do not differentiate between these behaviours empirically (see Frederiks et al., 2015 for an overview). Thus, they fail to explain why an energy efficiency label influences a purchase decision, for instance, but may hardly change electricity expenditures on the next bill.

It is well established and to some extent even intuitive knowledge that material factors such as house size, type of dwelling and construction materials, and socioeconomic factors such as the level of income significantly impact the amount of energy that is used in a home (e.g. Huebner et al., 2016; Lange et al., 2014). It is much less clear what leverage motivational factors and their impact on individual behaviour have for changing the total energy consumption of a household. Arguably, policy strategies aiming to increase energy efficiency and energy saving

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https://doi.org/10.1016/j.esd.2022.03.003

need to make use of all available and viable entry points, including individual motivation and behavioural aspects.

This study analyses the drivers of efficiency investments and curtailment behaviours of middle class households in Ghana, Peru and the Philippines, focusing on the relative importance of environmental concern and environmental knowledge. This far, the motivations for curtailment behaviours and energy efficiency investments have mainly been studied in Europe, the United States (e.g. Testa et al., 2016; Trotta, 2018) and in China (e.g. Yang et al., 2016). However, it is unclear whether the insights on the role of environmental concern and knowledge can easily be transferred to the context of middle income countries. This study therefore contributes to closing an empirical, policy-relevant research gap by capturing the links from individual motivation to behaviour and from behaviour to the impact on a household's total electricity consumption in Ghana, Peru and the Philippines. The findings will be put into perspective to ongoing policies.

Ghana, Peru and the Philippines are interesting countries to analyse and to compare precisely because they are not the largest carbon-emitting, energy-intensive countries in their respective regions, yet they are catching up quickly. They have experienced steady economic growth, a decline in poverty and an increasing electricity demand (IEA, 2020b; Burchi et al., 2019; Datt, 2017). Furthermore, they share several other characteristics that can be kept constant for comparison: substantial and growing urban middle classes that have started adopting an energy-intensive lifestyle (Never & Albert, 2021; Ramakrishnan et al., 2021), middle income country status (according to World Bank) and similar developments of power sectors in terms of privatization trajectories and electricity price reforms over time. In contrast, they are at different stages in the implementation of energy efficiency labels, making a comparison of consumers' efficiency investments particularly interesting: Ghana introduced its energy efficiency label in 2005. The label of the Philippines has been in place for only a few appliances since 1993, but it is currently being simplified, replaced and extended to more appliances. Peru introduced an energy efficiency label for the first time in 2017. Heterogeneous impacts of these labels on energy saving behaviours are possible.

We draw on a unique household survey of approximately 900 middle class households each in the capital cities of the three countries: Accra (Ghana), Lima (Peru) and Manila (Philippines). Our results reveal specific correlations between motivations, behaviour and electricity consumption, and contrast them to sociodemographic factors as control variables. The identification and relative importance of these channels of influence will be useful for designing energy saving policy interventions, which we discuss at the end of our paper. Understanding the behavioural context and its mechanisms can increase the effectiveness of energy efficiency policies (Kuhn et al., 2021), while negative effects of interventions on curtailment and investment behaviour could be avoided (McCoy & Lyons, 2017).

Literature review and hypotheses

Both types of energy saving behaviours, efficiency investments as well as curtailment, are shaped by a complex set of individual and contextual factors. This study focuses on the relative role of environmental concern and environmental knowledge in this mix. It further controls for sociodemographic factors that define personal capabilities (income, age, gender, education). Both psychological factors and sociodemographics matter for efficiency investments and curtailment behaviours. Yet, the literature remains remarkably unclear regarding the relative importance of these factors, especially in countries outside of Europe and the United States. As environmental concern and awareness have risen considerably in low and middle income countries in the past decade (World Value and Gallup Surveys, several years), investigating a potential effect of this trend on energy consumption behaviour promises interesting results of increasing relevance.

Energy efficiency investments are differentiated into low-cost investments (e.g. purchase of appliances) and high-cost investments (e.g. housing retrofits). For low-cost investments, upfront financial costs, amortisation periods and purchase frequencies depend on the type and durability of the respective product. For instance, whereas both a refrigerator and a light bulb are one-off appliance purchase decisions, costs and lifetime are different.

Energy efficiency investments can be influenced by a number of factors, ranging from information asymmetries, technology availability, market dynamics and electricity price (Allcott & Greenstone, 2012; Gillingham et al., 2009) to income and credit constraints (Figueroa et al., 2019; Gaspar & Antunes, 2011; Mills & Schleich, 2010). Other individual factors, such as time and risk preferences matter as well (Fuhrmann-Riebel et al., 2021; Never, 2016; Qiu et al., 2014; Streimikine et al., 2020; Volland, 2017). In this paper, we look at the role of environmental knowledge and concern in particular.

The roles of environmental concern and environmental knowledge for efficiency investments, especially the adoption of energy efficient appliances, have hardly been investigated in middle income countries this far. In their systematic review of studies on the behavioural dimension of energy conservation conducted in several high income countries, Karlin et al. (2014) find no effect of environmental concern on efficiency behaviours. The authors find that these are rather driven by demographics, structural, technical and financial factors. In some studies, self-reported pro-environmental behaviours, concern, attitudes and knowledge correlate positively with energy efficient appliance choice and curtailment behaviours (Barr et al., 2005; Nguyen et al., 2018; Trotta, 2018; Urban & Scasny, 2012), but not with high-cost efficiency investments such as housing retrofits (Trotta, 2018; Urban & Scasny, 2012). Other studies find that environmental concern has a higher impact on low-cost than on high-cost investments (Diekmann & Preisendörfer, 2003; Ramos et al., 2016). Furthermore, more information results in higher knowledge levels, but not always in behaviour change or energy savings (Abrahamse et al., 2005; Paco & Lavrador, 2017). Different types of motivational and economic rebound effects may be responsible for this (Santarius & Soland, 2018). Thus, it is useful to analyse the relations between motivation and behaviour first, subsequently followed by the standalone analysis of the relation between behaviour and final household electricity expenditure.

Overall, the observed impact of environmental concern and knowledge on efficiency investments in previous research is ambiguous. As we cannot statistically test null hypotheses, e.g. no relation between concern and investment, we opt for testing the general relation[1] (motivation to behaviour as first conceptual step):

> Environmental concern (H1) and environmental knowledge (H2) predict energy efficiency investments.

Curtailment behaviours require lower effort to perform and no upfront financial investment, but often need to break with previous habits and comfort (Umit et al., 2019). For curtailment behaviours, information, social and psychological factors such as environmental concern and knowledge play a larger role than market or technological considerations (Barr et al., 2005; Karlin et al., 2014; Trotta, 2018). There is clearer empirical evidence of positive impacts of environmental concern and environmental knowledge on curtailment behaviours (Barr et al., 2005; Jansson et al., 2010; Karlin et al., 2014; Testa et al., 2016; Trotta, 2018; Yang et al., 2016).

Yang et al. (2016) provide correlational evidence that the curtailment behaviours of Chinese urban residents are significantly and positively related to environmental responsibility and energy curtailment attitude, but also to sociodemographic factors such as female gender

[1] Note that the terms “relate” and “predict” indicate a correlational approach; we do not assume causal relationships for any of the hypotheses as we cannot test them with our survey data.

and being older. Using a self-selection online survey, Karlin et al. (2014) finds a significant effect of environmental concern on energy curtailment behaviour. Swedish university students concerned for the ecosystem (i.e. with strong biospheric values) are also more willing to curtail (Jansson et al., 2010). In contrast, other studies indicate that habits, perceived behavioural control and contextual factors can be more important for curtailment than intentions or social motivations (Maréchal, 2010; Van den Broek et al., 2019). The specific decision context in different countries could make a difference, calling for more empirical analyses. Studies in various fields, such as recycling or consumption of organic products, show that consumers who have a high environmental knowledge are more likely to act pro-environmentally (Bartkus et al., 1999; Peattie, 2010; Zepeda & Deal, 2009). Whether these findings hold in middle income country contexts has not yet been sufficiently answered.

We therefore predict[1] (also motivation to behaviour as first conceptual step):

Higher environmental concern relates positively with curtailment behaviours (H3).

More environmental knowledge relates positively with curtailment behaviours (H4).

Efficiency investments and curtailment behaviours have different effects on overall electricity expenditures. Households and companies that invest in energy efficiency can receive a lower electricity bill, unless rebound effects and other market failures occur (Allcott & Greenstone, 2012; Gillingham et al., 2009; Parikh & Parikh, 2016). Empirical studies that test the relationship between environmental concern and electricity use provide mixed results in industrialized countries. A few studies find negative correlations (Cramer et al., 1985; Sapci & Considine, 2014) or no correlation at all (Huebner et al., 2016; Ohler & Billger, 2014), while a recent study on Switzerland finds a positive correlation between environmental concern and electricity consumption (Enzler et al., 2019). Environmental concern as well as beliefs and norms are likely to influence saving behaviours, but not total energy consumption (Frederiks et al., 2015; Lange et al., 2014).

Curtailment behaviours alone rarely lead to a lower electricity bill, as rebound effects and (in)consistency of behaviours by all household members may offset initial savings (Charlier & Martinez-Cruz, 2020; Tabi, 2013; Brounen et al., 2021). In a recent analysis of energy saving behaviours in French households, Charlier and Martinez-Cruz (2020) find that habitual energy saving behaviours of household heads may not compensate for energy intensive behaviours of other household members and, thus, lead to no difference in overall household energy consumption.

Hence, we test the following directional hypothesis (behaviour to final expenditure outcome as second conceptual step):

Efficiency investments relate negatively with electricity expenditures (H5).

The literature suggests that curtailment behaviours have no significant effect on electricity expenditure, but we cannot statistically test this null hypothesis. Instead, we test the general hypothesis (also behaviour to final expenditure outcome):

Curtailment behaviours predict electricity expenditures (H6).

Finally, sociodemographics and the electricity price influence households' electricity consumption. Depending on the country and type of study, the effect sizes varies (Son & Yoon, 2020; Ye et al., 2018; Trotta, 2018; Testa et al., 2016; Yang et al., 2016; Mills & Schleich, 2010; Whitmarsh & O'Neill, 2010). In European countries, for instance, higher income levels are a more important predictor for efficiency investments than for curtailment behaviours (Umit et al., 2019; Urban & Scasny, 2012). In China, older residents and families with lower household incomes tend to engage more in curtailment, whereas education levels do not have a significant effect (Yang et al., 2016). In the Philippines, price and heat shocks can predict consumers adding or completely switching to other energy sources apart from electricity (Dacuycuy & Dacuycuy, 2018). In our model, we only include sociodemographics as control variables and, thus, refrain from discussing the comprehensive literature on sociodemographics and energy consumption in more detail. In this contribution, we are primarily interested in the role of environmental concern and knowledge.

Materials and methods

Data collection

The data was collected through surveys with 900 middle class households each in Accra, Lima and Manila, respectively, between October and December 2018. Previous research has shown that the new middle classes largely live in urban centers (Albert et al., 2018; Albert et al., 2020). The surveys were therefore conducted in the capital cities, as these attract a large share of middle class households. The data was collected by the authors and their staff (in the case of Ghana) and via additional sub-contracting professional market research agencies (in the case of Peru and the Philippines). The sampling, training of enumerators/interviewers and conduct of the door-to-door surveys in the field door-to-door was supervised by the authors on site in all three countries. The research process received ethical approval at the authors' institutions; participants signed informed consent forms, no minors were involved and no sensitive questions were asked. Participants could terminate the interview at any point and could withdraw consent by contacting the research agencies at a later stage. The data presented here is completely anonymized, ensuring full participant data protection. Participant signatures, author supervision of the data collection process and the automatic collection of geopoint locations of enumerators' tablet computers (via the survey software SurveyCTO) ensured that the sampled households actually participated and allowed us to conduct regular quality checks.

We prioritised approximating a representative sample size of middle classes in the respective capital cities over capturing more variation within countries by adding more cities (see Never et al., 2020 for details). Urban middle class households in Ghana, Peru and the Philippines all have stable access to the electricity grid and use electricity beyond lifeline tariffs, implying comparative conditions.

The sampling of households followed two steps: one geographical and one household-based step. In the first step, very poor areas and very rich districts were excluded. In the second step, a probability sampling proportional to the estimated population size for neighbourhoods was applied. Then, every fifth house from a random starting point was approached. In Accra, Ghana, the procedure was slightly adjusted. Since a large proportion of middle class households live in gated communities, we purposely approached 26 different gated neighbourhoods, which required a pre-registration of interviews. For each gated community, we randomly selected and approached one additional neighbourhood in the same district that was not gated. The resulting samples approximate a representation of the middle classes in each city; they are not meant to be representative of the national population. Table 1 in the following section gives an overview of the final sample size and sample characteristics for each country.

Measurement of variables and descriptive statistics

Environmental concern and environmental knowledge

Environmental concern and environmental knowledge are the independent variables of interest in this contribution. Environmental concern was measured with six survey items from Thøgersen et al. (2019), using a five-point Likert scale (see Appendix for details). We chose this measure over the new ecological paradigm (NEP) scale (Dunlap et al., 2000) because of its conciseness and previous successful

Table 1
Descriptive statistics.

Variable	n	Mean	sd	Min	Max
Ghana					
Log energy expenditure	844	4.4	0.7	1.8	6.8
Efficiency investment	876	0.6	0.5	0	1
Curtailment behaviour	876	4.4	0.7	1.7	5
Knowledge	876	5.6	1.6	0	8
Concern	876	4	0.6	1	5
Asset index	876	0	1.7	−4.3	3.6
Income decile	697	5.5	2.9	1	10
Number of rooms	846	3.9	1.6	1	12
Number of household members	876	4.5	2.1	1	16
Age of respondent	876	45.4	14.6	18	87
Education of respondent	876	2.8	0.9	0	5
Philippines					
Log energy expenditure	801	4.4	0.8	1.9	7.5
Efficiency investment	801	0.5	0.5	0	1
Curtailment behaviour	801	4.3	0.6	2	5
Knowledge	801	6.1	1.6	0	8
Concern	801	3.8	0.5	1.8	5
Asset index	801	0	1.6	−3.2	5.4
Income decile	801	5.5	2.9	1	10
Number of rooms	771	1.9	1	1	7
Number of household members	801	5.4	2.5	1	20
Age of respondent	801	38.2	12.5	18	65
Education of respondent	801	2.2	0.5	0	5
Peru					
Log energy expenditure	867	4.2	0.6	1.9	7.2
Efficiency investment	886	0.1	0.3	0	1
Curtailment behaviour	886	4.2	0.6	1	5
Knowledge	886	5.3	1.9	0	8
Concern	886	3.8	0.6	1	5
Asset index	886	0	1.6	−5.7	3.4
Income decile	886	5.5	2.9	1	10
Number of rooms	883	3.5	1.2	1	10
Number of household members	886	3.9	1.6	1	12
Age of respondent	886	48	14.8	19	75
Education of respondent	886	2.2	0.5	1	5

application in consumer research in middle income countries. The items form a construct with high reliability in all countries (Cronbach's alpha > 0.70). To measure environmental knowledge, we draw on Thøgersen et al.'s (2010) measure of environmental knowledge (see Appendix). We adapt their items to more closely capture knowledge about energy consumption. Items were constructed as questions with *yes*, *no* and *don't know* responses; the knowledge variable is the sum of correct responses. Scale reliability was satisfactory in all three countries (Cronbach's alpha between 0.50 and 0.70).[2]

Energy efficiency investment and curtailment behaviour

Energy efficient appliance purchase as a proxy for energy efficiency investments and an index of curtailment behaviours act both as dependent variables (to detect the impact of concern and knowledge) and as independent variables (to measure the effects on households' electricity expenditure). In our survey, we asked whether households own one or more appliance with the national energy efficiency label, simultaneously showing them a picture of the label. Based on these answers, energy efficiency appliance purchase is measured as a dummy variable. For exploratory purposes we also ask participants whether they know the energy label, whether they understand the label and whether they trust the energy label. We briefly present descriptive results to these questions in the results (see Section 0).

The index of curtailment behaviour is constructed as a mean index of three questions, which were all measured on a five-point Likert scale from *no*, *nearly never* to *yes*, *nearly always*:

- Do you usually switch off the lights when you leave the room?
- Do you usually tell or remind your friends or family members to switch off appliances when they leave the room?
- Do you actively try to save energy in your household?

The second and third question anticipate that motivation of other household members may be necessary to achieve overall energy saving and a lower electricity bill. Similar to most other studies in the field, we could not assess the actual behaviour and consumption of each member of the household separately. As in many other studies in the field, psychological motivation is measured at the individual level, while energy consumption is measured at the household level. The psychological literature deals with this challenge by assuming that interviewing a representative member of the household is sufficient to characterize the distribution of traits within the household (Sapci & Considine, 2014; Abrahmse & Steg, 2009; Gatersleben et al., 2002). As respondents were either household heads or purchase decision makers, we assume a substantial influence of the respondent on the behaviour of others in the home, especially on children.

Electricity consumption

To measure electricity consumption, we asked participants to share their last electricity bill with us and to guess their electricity expenditures. Especially in Peru and Ghana, many households were unable or unwilling to share their last electricity bill, which includes the total kWh used. Instead of the kWh, we therefore use the logarithm of (respondent estimated) electricity expenditures in purchasing power parities as a dependent variable. We took respondents' estimation of their electricity expenditures in those cases in which the last bill was not available or unclear.[3] Discussions with local research partners support our assumption that respondents' estimation about their latest electricity bills provides a more reliable estimate of energy consumption than respondents' estimation about their kWh consumption. We also asked respondents to show their latest electricity bill to enumerators. In Peru 28 respondents and in the Philippines 178 respondents were able to do so. We calculated a robustness check with the sub-samples of households that were able to provide their bill and correlated kWh with estimated expenditures, indicating estimated expenditure to be a reliable measure (Peru: $r = 0.80$, $p < 0.001$; Philippines: $r = 0.91$ $p < 0.001$).[4] Given this strong correlation, we decided to take it as our dependent variable in the analysis. Since it was not possible to attain the information on kWh consumption for every household we could not use it for the analysis. Furthermore, electricity prices are staggered according to the amount of kWh used in all three countries, which adds additional difficulties. As it is common we use the logarithm of the estimated energy expenditure for the analysis to account for the positively skewness of the variable.

[2] Measuring knowledge in terms of clear "yes" and "no" responses is likely to lead to more valid answers than using Likert-scales with uneven, unclear distances between degrees of knowledge. We expect the measurement bias resulting from adding the number of correct answers to be lower than from uneven distribution of a Likert scale and calculating the mean of answers.

[3] Some of the photos taken of the bills were blurred; others showed the accumulated debt of the household for several months, not the last month only.

[4] In Ghana nearly all households have a pre-paid metering system. Households recharge their meters on demand. Therefore, it is not possible to retrieve monthly kWh consumption from pre-paid bills. The billing period in Peru and the Philippines is monthly. The corresponding question in the questionnaire was: "Please give us your best guess how much you spent on electricity in the last month" (translated to Spanish/Tagalog, respectively). In Ghana, the prepaid meters are recharged by households when amounts are used up. Postpaid bills are monthly as well. To account for these differences, we asked two questions: 1. "Please give us your best guess how much you spent on electricity in total (in GHS)". 2. "Does the previous answer refer to spending by month or week?" If the answer corresponded to the week, we extrapolated the answer to a whole month (multiplying by four) to arrive at the monthly energy guess.

Control variables

As control variables, we include age, gender, education, household income, an asset index and the household size. For the choice of these control variables, we follow the literature on relevant sociodemographic factors for energy consumption (Lange et al., 2014; Marshall et al., 2016; Volland, 2017; Yang et al., 2016). As the type of dwelling was part of our sampling strategy for identifying middle class households, we do not include it as a control variable.

Education was measured as an ordinal variable with the following categories: 0 = no education or preschool, 1 = primary school, 2 = secondary, vocational or technical school, 3 = university education: bachelor degree or teacher training, 4 = university education: master degree, 5 = PhD. We computed income, based on households' monthly income, respondents' main wage and other earning from other occupations. To account for extreme outliers and right skewness of income distribution (in purchasing power parities), we use income deciles as a variable for our analysis. We include information on 12 assets[5] owned by the household (a1 = if owned at least once, 0 = if not owned). We use Principal Component Analysis (PCA) to summarize the amount of electricity-consuming assets the household owns in an asset index. Household size is measured via two variables: the number of rooms the household occupies, as well as the number of household members. These home size and occupancy variables can influence households' total electricity consumption, a study in the United Kingdom finds (Marshall et al., 2016). Table 1 shows the descriptive summary statistics of the main variables. The mathematical models summarizing our analysis are provided in the Appendix.

Results and discussion

We run the regressions for each dependent variable separately to be as scientifically rigorous as possible. We decided against running mediation models to avoid the pitfalls that come with this method such as unobserved indirect effects (Kline, 2015; Zhao et al., 2010, Fiedler et al., 2011). Due to the scales of the dependent variables, we run logistic regressions for energy efficiency investments (binomial variable of household adoption of appliances; hypothesis 1 and 2) and linear OLS regressions for curtailment (Hypothesis 3 and 4) and electricity expenditure (Hypothesis 5 and 6). All data analyses were conducted in R. We calculated linear regressions by using the *lm*( ) command and the *glm*(…,family = binomial) command for logistic regressions. The data was cleaned before the analysis: Obvious typos were corrected by agreement of two of the authors, and we visually examined the distribution of all variables. Visual outliers were found for income and energy spending. To account for outliers, we decided to use income deciles (deciles also smoothen the distribution of this control variable) and to exclude participants in the top and bottom 1% in energy spending. These are common practices in the energy and development economics literature.

Energy efficiency investments

Contrary to hypothesis 1 (environmental concern predicts energy efficiency investments), our results show that consumers' level of environmental concern in Ghana and the Philippines is largely unrelated to the households' energy efficiency investments. Only for Peru, we find a significant positive relation between both consumers' concern and knowledge and energy efficiency investments (Table 4). In line with hypothesis 2, the level of knowledge, however, positively

Table 2
Logistic regression results energy efficient investment (log odds) - Ghana.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.38*** [0.24, 0.53]	0.44*** [0.2,0.63]	0.41*** [0.24, 0.58]	0.43*** [0.21, 0.65]
Independent variables				
Knowledge	0.39*** [0.24, 0.53]	0.27** [0.11, 0.44]	0.23* [0.05, 0.40]	0.20* [0.01, 0.39]
Concern	0.05 [−0.09, 0.20]	0.05 [−0.10, 0.21]	−0.03 [−0.20, 0.14]	−0.01 [−0.18, 0.17]
Individual control variables				
Education		0.38*** [0.21, 0.55]		0.23* [0.01, 0.44]
Gender		−0.08 [−0.39, 0.23]		−0.04 [−0.40, 0.33]
Age		−0.37*** [−0.52, −0.21]		−0.34*** [−0.52, −0.15]
Household control variables				
Asset			0.52*** [0.31, 0.72]	0.42*** [0.20, 0.63]
Income decile			0.32** [0.12, 0.51]	0.21 [−0.00, 0.42]
Rooms			−0.10 [−0.31, 0.10]	−0.01 [−0.22, 0.21]
Household members			−0.03 [−0.22, 0.15]	−0.03 [−0.22, 0.16]
N	829	829	656	656
AIC	1095.16	1046.87	817.93	802.87
BIC	1109.32	1075.19	849.33	847.73
Pseudo R^2	0.05	0.13	0.16	0.20

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

correlates with energy efficiency investments in all three countries (Tables 2–4, Eq. (1) in the Appendix). The effect of environmental knowledge is significant at a minimum significance level of 5% throughout all countries and for all model specifications and ranges between $\beta = 0.2$ and 0.77.

Our findings support our general hypothesis H1 on a significant relation between concern and energy efficiency for Peru, but not for Ghana and the Philippines. Our analysis gives evidence for hypothesis 2, a positive relation between knowledge and energy efficiency investments, but we cannot claim causality. This mirrors the mixed findings in the literature. We refrain from any further interpretation of effect sizes of the logistic regression – as is common practice with these types of calculations. We merely point out that coefficients and effect sizes are in line with other studies analysing psychological variables (e.g. Yang et al., 2016) and that they indicate important tendencies.

We can further see that younger, higher educated Ghanaians, younger and male Peruvians and female Filipinos tend to purchase more efficient appliances. In all three countries, the number of assets a household owns seems to increase the likelihood that an energy efficient appliance is among them.

Since the energy efficiency label was freshly introduced in Peru during the survey period, results need to be treated with caution. It is possible that we see a first mover effect of those – rather few - households who have a particularly high level of environmental knowledge and environmental concern. Few respondents in Peru confirmed that they already know the label (23%) - and of these, only 20% understand the label, i.e. 5% of the total sample. On average, people trust the label in Peru; $M = 3.5$, $SD = 0.81$ (on a scale from 1 = strongly distrust to 5 = strongly trust, participants). In

[5] We include the following assets: fridge, freezer, rice cooker, microwave, washing machine, phone, laptop, desktop PC, stereo, water cooker, electric stove. For Ghana and the Philippines we include air conditioner and for Peru electrical heater.

Table 3
Logistic regression results energy efficient investment (log odds) - Philippines.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.03 [−0.11, 0.18]	−0.19 [−0.53, 0.14]	0.05 [−0.10, 0.20]	−0.34 [−0.71, 0.03]
Independent variables				
Knowledge	0.35*** [0.19, 0.50]	0.33*** [0.17, 0.49]	0.24** [0.07, 0.41]	0.24** [0.07, 0.41]
Concern	0.15 [−0.01, 0.31]	0.15 [−0.01, 0.31]	0.10 [−0.06, 0.27]	0.11 [−0.06, 0.27]
Individual control variables				
Education		0.27** [0.11, 0.43]		0.12 [−0.05, 0.30]
Gender		0.29 [−0.08, 0.66]		0.50* [0.09, 0.91]
Age		0.00 [−0.15, 0.15]		−0.09 [−0.25, 0.07]
Household control variables				
Asset			0.52*** [0.33, 0.72]	0.54*** [0.35, 0.74]
Income decile			0.24* [0.06, 0.42]	0.23* [0.05, 0.42]
Rooms			−0.01 [−0.19, 0.16]	0.01 [−0.17, 0.19]
Household members			0.00 [−0.18, 0.19]	−0.02 [−0.21, 0.17]
N	785	785	756	756
AIC	1062.43	1054.54	966.86	962.62
BIC	1076.43	1082.54	999.26	1008.90
Pseudo R^2	0.05	0.07	0.16	0.17

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table 4
Logistic regression results energy efficient investment (log odds) - Peru.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	−2.24*** [−2.49, −1.99]	−2.00*** [−2.33, −1.67]	−2.38*** [2.68, −2.09]	−2.13*** [−2.51, −1.75]
Independent variables				
Knowledge	0.77*** [0.51, 1.04]	0.69*** [0.41, 0.96]	0.64*** [0.36, 0.92]	0.54*** [0.26, 0.82]
Concern	0.44*** [0.24, 0.63]	0.37*** [0.17, 0.58]	0.43*** [0.22, 0.64]	0.37*** [0.15, 0.59]
Individual control variables				
Education		0.13 [−0.06, 0.32]		0.08 [−0.12, 0.27]
Gender		−0.69** [−1.15, −0.23]		0.73** [−1.22, −0.23]
Age		−0.47*** [−0.69, −0.25]		−0.05*** [−0.74, −0.26]
Household control variables				
Asset			0.73*** [0.45, 1.01]	0.74*** [0.45, 1.04]
Income decile			−0.10 [−0.35, 0.14]	−0.18 [−0.44, 0.08]
Rooms			−0.22 [−0.49, 0.05]	−0.12 [−0.41, 0.17]
Household members			0.19 [−0.03, 0.40]	0.16 [−0.09, 0.40]
N	849	849	817	817
AIC	583.59	559.65	540.92	519.26
BIC	597.83	588.11	573.86	566.31
Pseudo R^2	0.12	0.19	0.19	0.25

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
* $p < 0.05$.
*** $p < 0.001$.
** $p < 0.01$.

Ghana and the Philippines, the energy efficiency labels are more well-known (83% of Ghanaian respondents know it and 68% in the Philippines). The Ghanaian star label is easier to understand than the old Philippine label: 70% of respondents in Accra and 64% of respondents in Manila said they understand the label at least to some extent. Trust in the labels is similar in Ghana ($M = 3.6$, $SD = 0.84$) and in the Philippines (M = 3.6, SD = 0.66). After the data collection, the Philippines introduced a new star rating label. While the energy efficiency labels may guide purchase decisions, consumers do not seem to make a mental link between broader environmental issues and values and the label.

A lack of environmental concern is unlikely to be a reason for these results: means of environmental concern are high in all three countries (see Table 1). Rather, electricity pricing and thrift may be additional drivers of purchase behaviour that we could not directly test for. Moreover, the availability of labelled appliances in stores and marketplaces, as well as the information campaigns by utility providers, can make a difference – also to knowledge levels. The Philippine electricity provider Meralco has been very active in advocating for energy saving for several years, including radio and social media campaigns and sending reminders via text messages. In contrast, Enel and Luz del Sur, the major electricity providers in Lima, are only starting to pick up energy efficiency and saving approaches. Ghana's electric utility provider has focused on supply security for a long time and seeks to shave peak load rather than achieve overall energy efficiency. Since the early to mid-2000s, the regulating Energy Commission has pushed for more systematic energy efficiency programmes, including a "No label, no good" campaign (Agyarko et al., 2020; Gyamfi et al., 2018). In all three countries, information campaigns to energy saving are rarely connected to environmental issues that raise concern – in contrast to many European countries.

The significance of some of the sociodemographics confirms that, overall, both psychological and sociodemographic factors matter for energy efficiency investment decisions. Our results uncover their relative importance, but also indicate that neither are able to explain the complexity of investment decisions completely. Sociocultural differences may be responsible for the differences we see between Ghana, Peru and the Philippines. In the Philippine sample, we have a higher share of female respondents as women often present the decision maker for household items. As sociodemographic factors present control variables only in this study, we refrain from further speculation about country variations here.

Curtailment behaviour

As expected, we find that a higher level of environmental concern predicts an increase in curtailment behaviours in all three countries, supporting hypothesis 3 (see Tables 5–7, Eq. (2) in Appendix). In our data, participants with higher environmental concern are more likely to conduct curtailment behaviours than participants with low environmental concern. In Ghana, for example, an increase in one unit of concern on our scale, on average, increases curtailment behaviours on our

Table 5
Regression results curtailment - Ghana.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	4.40***	4.33***	4.36***	4.30***
	[4.35, 4.44]	[4.27, 4.39]	[4.31, 4.41]	[4.23, 4.37]
Independent variables				
Knowledge	−0.05*	−0.06*	−0.03	−0.04
	[−0.10, −0.00]	[−0.11, −0.01]	[−0.09, 0.03]	[−0.10, 0.02]
Concern	0.12***	0.11***	0.10***	0.09**
	[0.07, 0.18]	[0.06, 0.17]	[0.04, 0.16]	[0.03, 0.15]
Individual control variables				
Education		0.06*		0.08**
		[0.01, 0.11]		[0.02, 0.15]
Gender		0.16***		0.16**
		[0.07, 0.25]		[0.05, 0.27]
Age		0.11***		0.11***
		[0.07, 0.15]		[0.06, 0.17]
Household control variables				
Asset			−0.00	−0.01
			[−0.06, 0.06]	[−0.07, 0.05]
Income decile			−0.02	−0.02
			[−0.08, 0.04]	[−0.08, 0.05]
Rooms			−0.00	−0.03
			[−0.07, 0.07]	[−0.10, 0.04]
Household members			−0.00	0.01
			[−0.06, 0.06]	[−0.04, 0.07]
N	829	829	656	656
AIC	1691.64	1664.19	1369.50	1348.09
BIC	1710.52	1697.24	1405.39	1397.44
Adj. R^2	0.03	0.06	0.01	0.05

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table 6
Regression results curtailment - Peru.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	4.15***	4.09***	4.14***	4.07***
	[4.11, 4.19]	[4.02, 4.16]	[4.10, 4.19]	[4.00, 4.14]
Independent variables				
Knowledge	0.02	0.04	0.04	0.06*
	[−0.02, 0.07]	[−0.01, 0.09]	[−0.01, 0.09]	[0.01, 0.11]
Concern	0.05*	0.07**	0.05*	0.07**
	[0.01, 0.09]	[0.03, 0.12]	[0.00, 0.10]	[0.02, 0.12]
Individual control variables				
Education		−0.02		−0.10
		[−0.06, 0.02]		[−0.06, 0.03]
Gender		0.11*		0.13**
		[0.02, 0.20]		[0.04, 0.22]
Age		0.10***		0.10***
		[0.05, 0,14]		[0.06, 0.15]
Household control variables				
Asset			−0.08**	−0.08**
			[−0.13, −0.03]	[−0.13, −0.03]
Income decile			0.05	0.05
			[−0.01, 0.11]	[−0.00, 0.11]
Rooms			−0.03	−0.05*
			[−0.08, 0.02]	[−0.10, −0.00]
Household members			−0.03	−0.01
			[−0.07, 0.02]	[−0.06, 0.03]
N	849	849	817	817
AIC	1644.05	1622.77	1578.36	1555.11
BIC	1663.03	1655.98	1616.01	1606.87
Adj. R^2	0.01	0.03	0.02	0.05

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

scale by 0.09, c.p.[6] In everyday language, this relative increase can be understood as rather moderate. The null hypothesis of finding no effect of concern on curtailment in Ghana can be rejected with an error probability of 1%. However, correlation coefficients are small in the Peruvian and Filipino samples.

Surprisingly, in all three countries, more environmental knowledge does not predict the adoption of curtailment behaviours (hypothesis 4, Eq. (2) in Section 0). Only in Peru, we find a small significant effect when controls are included, indicating a rather unrobust finding. It should be noted that our environmental knowledge scale has been explicitly adapted to the energy context, so that environmental knowledge is not general but specific to the context. The results are in line with findings among households in industrialized countries on the knowledge – action gap (Kollmuss & Agyeman, 2002). Additionally, individual level control variables influence curtailment, whereas household level variables do not impact curtailment. Older participants in all three countries, female participants in Ghana and Peru, higher educated participants in Ghana and the Philippines are more likely to curtail.

The goodness of fit of our models are very limited, even for psychological studies on this topic. On the one hand, this may mean that we did not ask the right questions or included all relevant variables, casting doubts on this linear relationship. However, the goal of our study was not to explain curtailment behaviour in its entirety, but to find out more about the relative importance of environmental concern and knowledge as drivers, among the many factors influencing energy saving behaviour. On the other hand, our results rather uncover a relative tendency and imply that several other, unobserved variables might influence curtailment behaviour. This is a relevant result as such.

Perceived behavioural control and the decision context in the home are likely unobserved, but influential factors (Maréchal, 2010; Van den Broek et al., 2019). Furthermore, the electricity price, respondents' thrift or external information such as reminders by electricity providers may have had an effect. Overall, the vast majority of respondents reports practicing energy saving behaviours (see Table 1). In 2018, a household that consumed 200 kWh of electricity per month paid 117 Cedi/57 USD-PPP in Accra (PURC, 2018), 1018 PHP/52 USD-PPP in Manila (Meralco, 2018) and 110 Soles/63 USD-PPP in Lima.[7] For comparison: on average, a German household pays 81 USD-PPP and a US household 26 USD-PPP for 200 kWh of electricity (in 2020). It is therefore credible that middle class households in Ghana, Peru and the Philippines try to save energy, but rather for cost reasons than for environmental ones. For the design of demand-reduction programmes, our results imply that more information on energy saving options are helpful, but focusing on information campaigns alone is unlikely to lead to the desired results. Also, expectations that encouraging and expanding environmental concern and knowledge results in large, significant behaviour changes is likely

[6] While this information gives no absolute, tangible numbers, it still gives a relative indication of relevance. Additionally, it is meant as an interpretation help here for readers unfamiliar with reading regression tables.

[7] For Lima prices, we took the 2018 cost by Enel for residential areas of 0.5073 Sol/kWh for households consuming more than 100 kWh (taken from photos of electricity bills), adding estimates for power factor and transmission charges. Some households also pay additional street lighting charges, others pay interest rates on previous unpaid bills. This makes a comparison of actual costs difficult.

Table 7
Regression results curtailment - Philippines.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	4.31***	4.35***	4.32***	4.34***
	[4.27, 4.35]	[4.26, 4.43]	[4.28, 4.36]	[4.25, 4.43]
Independent variables				
Knowledge	0.01	0.00	0.00	−0.00
	[−0.03, 0.05]	[−0.04, 0.04]	[−0.04, 0.05]	[−0.04, 0.04]
Concern	0.05*	0.05*	0.04*	0.04*
	[0.00, 0.09]	[0.00, 0.09]	[0.00, 0.08]	[0.00, 0.09]
Individual control variables				
Education		0.05**		0.04*
		[0.01, 0.08]		[0.00, 0.07]
Gender		−0.04		−0.02
		[−0.14, 0.05]		[−0.12, 0.08]
Age		0.05**		0.04*
		[0.01, 0.10]		[0.00, 0.09]
Household control variables				
Asset			0.07**	0.06**
			[0.03, 0.12]	[0.02, 0.11]
Income decile			−0.03	−0.03
			[−0.07, 0.02]	[−0.08, 0.02]
Rooms			−0.01	−0.01
			[−0.05, 0.04]	[−0.06, 0.03]
Household members			−0.06*	−0.05*
			[−0.10, −0.01]	[−0.09, −0.00]
N	785	785	756	756
AIC	1347.79	1341.66	1298.33	1297.68
BIC	1366.45	1374.32	1335.35	1348.59
Adj. R^2	0.00	0.02	0.02	0.03

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

misleading. The effect is likely limited to a sub-set of households, as our results show.

Electricity expenditure

This study sought to analyse the whole chain between concern/knowledge, behaviour and households' electricity expenditure as a proxy for final monthly electricity consumption. The regression results in Tables 8–10 show that, overall, sociodemographics have a stronger effect on (the log of) electricity expenditure than motivations (concern and knowledge), energy efficient appliance purchase and curtailment behaviour. The goodness of fit of our models are in the same range as other, similar studies on the very complex puzzle of energy consumption in households.

An increase of one unit of the asset index, on average, is associated with an increase in the average monthly electricity expenditure by a Ghanaian household by 23. 36%, c.p. (Table 8). In lay terms, we find a sharp increase: more appliances in the house show up very clearly on the electricity bill. The probability to find null effect can be discarded with an error probability of 0.1%. Furthermore, the addition of one more room in a Ghanaian household, on average, is associated with an increase of 15% in monthly electricity expenditure (2010), c.p. (significant at 0.1% level). In the Philippines, we see a similar effect of household rooms; one more room is associated with a 17% increase in monthly electricity expenditure (2010), c.p. The pattern for the asset index is the same as for Ghana (Table 10). In both Peru and the Philippines, for example, the shift of a household to one higher income decile is associated with an increase of average monthly electricity expenditure in USD-PPP by 9,4% (Table 9). These results add to findings

Table 8
Regression results (log of) electricity expenditure in PPP - Ghana.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	4.27***	4.26***	4.32***	4.30***
	[4.20, 4.34]	[4.18, 4.35]	[4.25, 4.40]	[4.22, 4.38]
Independent variables				
Curtailment	−0.01	−0.02	0.00	−0.00
	[−0.06, 0.04]	[−0.07, 0.02]	[−0.04, 0.04]	[−0.05, 0.04]
Efficiency investment	0.24***	0.18***	0.08	0.07
	[0.15, 0.34]	[0.09, 0.28]	[−0.01, 0.18]	[−0.03, 0.17]
Individual control variables				
Education		0.15***		0.04
		[0.10, 0.19]		[−0.01, 0.09]
Gender		0.09		0.08
		[−0.00, 0.18]		[−0.01, 0.17]
Age		0.02		−0.02
		[−0.03, 0.06]		[−0.06, 0.03]
Household control variables				
Asset			0.23***	0.21***
			[0.17, 0.28]	[0.15, 0.27]
Income decile			0.07*	0.06*
			[0.02, 0.13]	[0.00, 0.12]
Rooms			0.14***	0.14***
			[0.09, 0.19]	[0.09, 0.20]
Household members			0.05	0.05
			[−0.00, 0.10]	[−0.00, 0.10]
N	829	829	656	656
AIC	1697.65	1667.54	1140.09	1140.47
BIC	1716.53	1700.58	1175.98	1189.82
Adj. R^2	0.03	0.07	0.29	0.29

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
** $p < 0.01$.
*** $p < 0.001$.
* $p < 0.05$.

of Son and Yoon (2020) on significant impacts of income on electricity consumption in Vietnam and by Musango (2014) on South African households. The coefficients for the asset index in Peru is slightly lower than in the other two countries and the number of people in the household is relevant, but not the number of rooms.

We expected a negative relation between energy efficiency investments and electricity expenditure, i.e. households that invest more in energy efficiency spend less on their electricity bill (hypothesis 5, Eq. (3) in the Appendix). Yet, our results show no significant correlation in this direction. Contrary to our hypothesis, the analysis of the Philippine data even reveals a significant positive effect of efficiency investments on electricity expenditure. This may be due to the correlation; that households with a high number of assets are more likely to own at least one energy efficient appliance. It could also be due to the reason that the Filipino energy efficiency label has been introduced in place for more appliances for a longer time period, compared to the other two countries where only few appliances receive labelling. Another explanation might be a rebound effect that owning efficient appliances licenses consumers to use more energy. For Peru, limited consumer information on energy saving and the very recent introduction of the energy efficiency label is very likely to be responsible for the finding. Furthermore, the results show that, contrary to our predictions in all three countries, curtailment behaviours do not affect households' electricity expenditure (hypothesis 6, Eq. (3) in the Appendix). We do not find evidence that respondents who regularly try to save energy have lower energy expenditures in their households than households who do not. In all three countries, the number of assets, income

Table 9
Regression results (log of) electricity expenditure in PPP - Peru.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	4.15*** [4.11, 4.19]	4.16*** [4.10, 4.22]	4.16*** [4.12, 4.19]	4.16*** [4.10, 4.21]
Independent variables				
curtailment	−0.02 [−0.06, 0.02]	−0.03 [−0.07, 0.01]	−0.01 [−0.04, 0.043]	−0.02 [−0.05, 0.02]
Efficiency investment	0.09 [−0.02, 0.19]	0.11 [−0.00, 0.21]	−0.03 [−0.13, 0.07]	0.00 [−0.11, 0.11]
Individual control variables				
Education		0.04* [0.01, 0.08]		0.01 [−0.03, 0.04]
Gender		−0.03 [−0.10, 0.05]		−0.01 [−0.08, 0.06]
Age		0.09*** [0.05, 0.13]		0.08*** [0.04, 0.11]
Household control variables				
Asset			0.17*** [0.13, 0.21]	0.17*** [0.12, 0.21]
Income decile			0.10*** [0.06, 0.14]	0.09*** [0.05, 0.13]
Rooms			−0.00 [−0.05, 0.04]	−0.02 [−0.06, 0.03]
Household members			0.06** [0.02, 0.10]	0.08*** [0.03, 0.12]
N	849	849	817	817
AIC	1389.96	1368.01	1163.14	1150.72
BIC	1408.94	1401.21	1200.79	1202.48
Adj. R^2	0.00	0.03	0.20	0.21

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table 10
Regression results (log of) electricity expenditure in PPP - Philippines.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	4.26*** [4.19, 4.33]	4.25*** [4.12, 4.37]	4.37*** [4.31, 4.43]	4.28*** [4.18, 4.38]
Independent variables				
Curtailment	−0.01 [−0.06, 0.03]	−0.03 [−0.07, 0.02]	−0.02 [−0.06, 0.02]	−0.02 [−0.06, 0.02]
Efficiency investment	0.36*** [0.27, 0.46]	0.35*** [0.25, 0.44]	0.15*** [0.07, 0.24]	0.15*** [0.06, 0.23]
Individual control variables				
Education		0.07** [0.02, 0.11]		0.01 [−0.04, 0.05]
Gender		0.03 [−0.10, 0.16]		0.11* [0.01, 0.22]
Age		0.10*** [0.05, 0.14]		0.05* [0.01, 0.09]
Household control variables				
Asset			0.21*** [0.17, 0.26]	0.21*** [0.16, 0.26]
Income decile			0.08*** [0.03, 0.13]	0.09*** [0.04, 0.14]
Rooms			0.16*** [0.12, 0.20]	0.16*** [0.11, 0.20]
Household members			0.12*** [0.08, 0.17]	0.12*** [0.08, 0.16]
N	785	785	756	756
AIC	1598.87	1584.02	1246.97	1242.88
BIC	1617.53	1616.68	1284.00	1293.79
Adj. R^2	0.07	0.09	0.38	0.38

All continuous predictors are mean-centered and scaled by 1 standard deviation. Confidence intervals are shown in squared brackets and are calculated based on heteroskedasticity robust standard errors.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

and household size have a clear positive effect on electricity expenditure. This is in line with previous research in the UK that finds that building and appliance ownership as well as household size explain a much larger share of electricity consumption than attitudes and reported behaviours (Huebner et al., 2016). Our results tentatively indicate that especially wealthier households with bigger houses spend more on electricity.

Rebound effects due to a more intensive usage of energy efficient appliances – or of other, inefficient appliances – may offset energy savings, both by energy efficiency investments and curtailment. As the asset index of electricity using appliances is the strongest predictor of electricity expenditure, either the number of appliances in use or their energy intensity is most likely to impact households' final electricity consumption, i.e. electricity expenditures. In many developing economies in tropical climate zones, air conditioners, lighting, electric fans and refrigerators account for the largest share of household electricity consumption (Adeoye & Spataru, 2019; McNeil et al., 2019). We ran an additional robustness check, calculating the ratio between energy efficient and non-efficient appliances in the household and re-ran the regression with the ratio instead of the asset index of all electricity-consuming appliances. Results did not change. In line with the findings of Charlier and Martinez-Cruz (2020), positive effects of curtailment behaviours by the respondent may have also been countered by the behaviours of other household members. Disregarded variables in our models such as the behaviour of other household members as well as the building structure are very likely to account for the unexplained variance, as is common in any survey approach to these type of research questions. The limitation of measuring stated, rather than actual revealed decisions and behaviours applies as well.

In sum, our findings and, thus, conceptual links between motivations, behaviours and electricity consumption (expenditure) are less clear than expected. The number of owned electricity consuming assets, income levels and household size are more important predictors of electricity consumption in middle class households than environmental concern and knowledge via efficiency investments and curtailment. This even holds true for households reporting to frequently conduct curtailment behaviours.

Conclusions and policy implications

This study provides new empirical evidence on the relations between environmental concern and knowledge, energy efficiency investments and curtailment behaviours, and electricity expenditure among middle class households in three middle income countries. Results from our household surveys in Ghana, Peru and the Philippines show that environmental concern positively predicts curtailment behaviours, but not energy efficiency investments (exception Peru, but to be treated with caution). In turn, higher levels of environmental knowledge make energy efficiency investments more likely, but not curtailment behaviour. Neither curtailment behaviours nor energy efficiency investments significantly reduce households' electricity expenditures. Table 11 summarizes all results in a concise way.

In all three countries, increasing income and a higher number of electrical appliances owned by the household clearly predict more electricity expenditures. Larger households, either in terms of members (Philippines, Peru) or rooms (Ghana) do so as well. Surprisingly, we

Table 11
Overview of regression results (+ indicating a positive relationship, − a negative relationship, n.s. non-significant).

		Energy efficiency investment	Curtailment	Electricity expenditures
Ghana	Environmental knowledge	+	–	
	Environmental concern	n.s.	+	
	Curtailment			n.s.
	Energy efficiency investment			+
Philippines	Environmental knowledge	+	n.s.	
	Environmental concern	n.s.	+	
	Curtailment			n.s.
	Energy efficiency investment			+
Peru	Environmental knowledge	+	n.s.	
	Environmental concern	+	+	
	Curtailment			n.s.
	Energy efficiency investment			n.s.

do not see that energy efficiency investments significantly reduce electricity expenditures. In line with the literature, curtailment behaviours do not influence the electricity bill either. These results point towards rebound effects or mixed usage behaviours by different household members. The person purchasing an energy efficient appliance for environmental reasons may not be able to influence all other household members to use devices in an energy saving fashion. Furthermore, households owning energy efficient appliances generally tend to own more appliances.

Due to data restrictions, our study has some limitations. We could not measure the influence of staggered electricity tariffs on both behaviour and households' electricity expenditure. To some extent, the usual restrictions of stated vs. revealed behaviours apply to our surveys as well. Furthermore, our research established correlations, not causation – a restriction that applies to many similar studies. Finally, in line with other studies assessing complex energy consumption decision-making in households including psychological factors (e.g. Trotta, 2018; Yang et al., 2016), the overall predictive power of our models is somewhat limited, particularly regarding environmental concern and curtailment behaviour. Future research could provide closer analyses of the causal interactions between environmental concern, knowledge and other behavioural factors such as perceived behavioural control and the behaviour of other household members.

Several policy implications result for energy efficiency programme designers and regulators of the energy sector. First, behaviour change campaigns that seek to foster energy saving in households in middle income countries need to explicitly target the rising middle classes and develop programmes that engage all members of the household to avoid rebound effects. Second, information campaigns alone and especially a mere focus on increasing environmental concern and attitudes are unlikely to be sufficient to change both investment and curtailment behaviours of all household members and, ultimately, total electricity consumption at the end of the month. Combined approaches that give tailored information and seek to change the decision context for purchase and usage behaviours could be more effective, e.g. feedback on past consumption on the electricity bill combined with a saving scheme for more efficient appliance purchases or with a rebate scheme. The stricter tailoring of campaigns may be useful to account for other variations within countries such as cultural backgrounds as well (Wiyaya & Tezuka, 2013). For Peru, information campaigns to raise awareness of and trust in the new energy efficiency label may still present a useful first step. Systematic controls of minimum energy performance standards – usually tied to labelling programmes – could further enhance consumer trust in the labels in all three countries. Finally, our results imply that with rising income and spending capacities, electricity peak load management will become even more challenging as more households use more assets at the same time. Supply- and demand-side management thus needs integrative planning in middle income countries with growing middle classes. More explicitly, integrating housing and construction factors in energy planning may be useful, as the household size (number of rooms) also play a role for energy consumption. Here, many middle income countries are still at the beginning of the policy journey.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are grateful for the financial support of the German Federal Ministry of Education and Research (BMBF). We would also like to thank the respondents to our survey for their patience and our research assistants for their support.

Appendix A*Environmental concern scale items:*

1. It is important to me that the products I use do not harm the environment.
2. I consider the potential environmental impact of my actions when making many of my decisions.
3. My purchase habits are affected by my concern for our environment.
4. I am concerned about wasting the resources of our planet.
5. I would describe myself as environmentally responsible.
6. I am willing to restrict myself in order to take actions that are more environmentally friendly.

Environmental knowledge scale items:

1. I know a lot about the topic of global climate change.
2. I know quite a lot about the different possibilities how to save energy in my household.
3. Compared with others, I have a good understanding of the impact of transport on air pollution.
4. You can save energy when you set your air conditioner two degrees warmer.
5. Using a lot of energy has a negative impact on the environment.
6. You can save energy and money in the long run when you buy a new fridge with energy-efficient technology.
7. Whether I leave the light on the whole day or turn it off when I leave the room does matter for my energy consumption.
8. Using public transport instead of a private car is better for the environment.

Regression models

Hypothesis 1 and 2: energy efficiency investment

Households' adoption of energy efficient appliances is modelled within a logistic regression framework:

$$y^* = x\,\beta + \varepsilon$$

where y^* is a latent variable denoting the household's preference for energy efficient appliances, x is a vector of explanatory variables (environmental knowledge and concern), β is a vector of parameters to be estimated, and ε is the error term. While preferences cannot be directly observed, the decision to invest in energy efficient appliance is observed according to the following decision rule:

$y = 0$ (household does not own any appliance with national efficiency label) if $y^* < 0$
$y = 1$ (household owns one or more appliances with national efficiency label) if $y^* \geq 0$

The logit function of the odds O that a household invests in energy efficient appliances is given by

$$\ln(O) = \ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_i + \beta_4 W_i \Rightarrow \frac{\partial \ln O}{\partial x_j} = \beta_j$$

where X_1 indicates concern, X_2 indicates knowledge, X_i indicates all individual level control variables, W_i indicates all household level control variables and β_j denotes the effect.

Hypotheses 3 and 4: curtailment behaviour

To analyse the role of environmental concern and environmental knowledge for curtailment behaviour, we use the following OLS regression

$$Y_i = ß_0 + ß_1 \mathit{Environmental\ Concern}_i + ß_2 \mathit{Environmental\ Knowledge}_i + ß_3 X_i + ß_4 W_i + u_i$$

where Y_i is one of either energy efficient appliance purchase or curtailment behaviour, X_i indicates all individual level control variables, W_i indicates all household level control variables and u_i is the error term.

Hypotheses 5 and 6: electricity expenditures

To analyse the role of energy efficient appliance purchases and curtailment behaviour for monthly electricity expenditures, we use the following OLS regression

$$Y_i = ß_0 + ß_1 \mathit{Energy\ Efficient\ Appliance\ Purchase}_i + ß_2 \mathit{Curtailment\ Behaviour}_i + ß_3 X_i + ß_4 W_i + u_i$$

where Y_i is households' log of monthly electricity expenditures, X_i indicates all individual level control variables, W_i indicates all household level control variables and u_i is the error term.

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