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Energy Poverty in Ireland

Analysis of 2023 data from the Behavioural Energy and Travel Tracker

SEAI Behavioural Economics Unit

Behavioural insights for policy: primary research

Rialtas na hÉireann
Government of Ireland

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Sustainable Energy Authority of Ireland
SEAI is Ireland's national energy authority investing in, and delivering, appropriate, effective and sustainable solutions to help Ireland's transition to a clean energy future. We work with the public, businesses, communities and the Government to achieve this, through expertise, funding, educational programmes, policy advice, research and the development of new technologies.

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Background

Sharp increases in energy prices due to the recent energy crisis layered into a broader cost-of-living crisis have brought the topic of energy poverty further into the mainstream of academic and policy spheres. Tracking energy poverty over time and targeting supports requires first choosing an appropriate measure. While there are many ways to measure energy poverty, little is known about how these measures interact and overlap, how they vary at different times of year and how they relate to energy behaviour. There is currently no consensus on a best measure.

This report uses the rich dataset generated by Ireland's Behavioural Energy and Travel Tracker (BETT) to provide a detailed and multifaceted picture of energy poverty in Ireland and address some of the gaps in the literature highlighted above. We analyse data concerning three self-reported measures of energy poverty, as well as a commonly used expenditure-based measure:

- Having difficulty paying energy bills
- Going without heating
- Cutting back on essentials
- Spending 10% or more of household income on energy costs

Findings are based on monthly data collected throughout 2023 from a nationally representative sample of 1,000 people for each survey wave.

Main findings

- Energy poverty was highly prevalent in Ireland throughout 2023, although estimates vary according to the measure used. On average across the year,
  - two in five billpayers had difficulty paying their last bill,
  - 23% had gone without heating in the preceding month,
  - three in ten had cut back on essentials in the preceding month to afford heating, and
  - 42% of participants spent 10% or more of their monthly income on energy costs.
- There are seasonal trends in the proportion of people spending more than 10% of their income on energy costs and going without heating. But the proportion having difficulty paying bills and cutting back on essentials remained consistent across the year.
- Most people experiencing energy poverty are categorised as such by more than one measure. For example, four in five people who went without heating in the preceding month or were cutting back on essentials still had difficulty paying their bills. The overlap between the expenditure-based measure and self-reported measures was lower however - one third of people spending 10% of income on energy were not experiencing energy poverty according to any of our other three measures.
- The sociodemographic factors most strongly associated with being in energy poverty include lower income, being a renter and the presence a disability in the household. Some of the characteristics associated with energy poverty change depending on the measure used. For example, families are more likely to have difficulty paying bills than single person households, but less likely to go without heating. Older people, a group typically thought to be at higher risk of energy poverty, were more likely to spend over 10% of their income on energy but were in fact less likely to be experiencing energy poverty according to our subjective measures.
- Self-reported measures of energy poverty were validated by participants' heating behaviour. People who reported going without heat in the preceding month heated their homes for a full hour less a day on average. Those who reported cutting back on essentials also heated their homes less, but those spending 10% or more of income on energy costs used more heating and were more likely to heat unoccupied space.

Conclusion

BETT has allowed us to shine a light on the groups of people in Ireland who are more vulnerable to energy deprivation, the seasonality of some aspects of energy poverty, and its multidimensionality.

Our analysis supports critiques of the 10% expenditure measure of energy poverty. The significant minority spending 10% or more of their income on energy costs but not experiencing energy poverty according to any subjective measure suggests that the expenditure measure includes people who can comfortably spend a high proportion of their income on energy. This is further supported by the relationship between high energy expenditure and inefficient heating behaviour. Additionally, the proportion of people under-consuming energy to the point their energy costs are below the 10% threshold, supports claims that the expenditure measure excludes people inadequately heating their homes to manage energy costs.

We make some recommendations based on these findings in the box below.

Recommendations

- Use subjective measures of energy poverty rather than relying on the 10% expenditure measure, as these are better at representing the experiences of the energy poor.
- Use multiple measures to reduce the risk of excluding vulnerable groups and better capture the multidimensionality of energy poverty.
- Collect energy poverty data at multiple points in the year to minimise the effects of recency bias on self-reported measures, and bear in mind the limitations of figures collected at one point in time.
- Further tailor energy poverty policies and supports to the groups most at risk. These include people on lower incomes, renters, households in which someone has a disability, lower social grades, those with lower educational attainment, and those living in homes with poorer BERs. For example:
  - Introduce the legislation mandating minimum energy efficiency standards in the private rental sector that was committed to in the 2021 Housing for All plan to further incentivise the uptake of retrofitting grants by landlords.
  - Prioritise people with disabilities on the Warmer Homes Scheme waiting list.
- Explore the possibility of energy saving advice to alleviate some of the burden of energy poverty in tandem with more substantial supports.

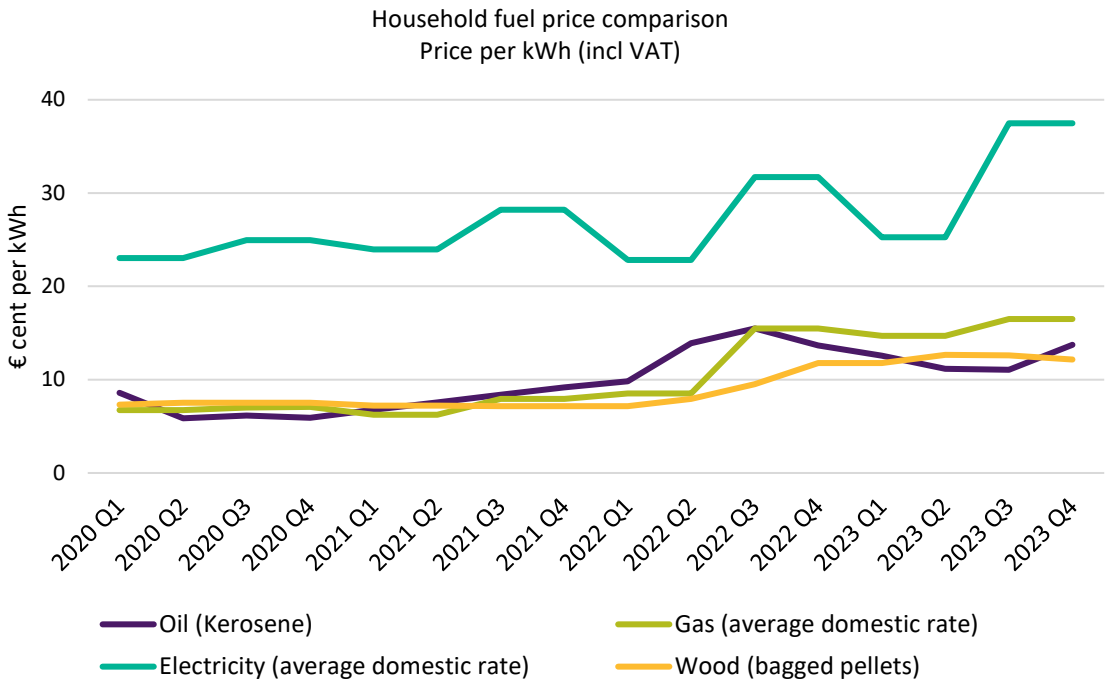
1. Introduction

1.1. Background

Sharp increases in energy prices due to the recent energy crisis layered into a broader cost-of-living crisis have brought the topic of energy poverty further into the mainstream of academic and policy spheres. In 2022, the Economic and Social Research Institute (ESRI) estimated the proportion of people spending 10% of their household income on energy bills in Ireland reached 29%, its highest recorded rate.[1] The Irish government developed the Energy Poverty Action Plan in 2022[2] and now funds a multi-stakeholder research initiative focusing on energy poverty led by the ESRI.

Energy poverty is often conceptualised as a three-sided issue, comprised of energy efficiency of the home, income, and the cost of energy.[3,4] By the end of 2023, gas and oil prices had doubled since the start of 2021, and the cost of electricity and wood increased by more than 50% (Figure 1).[5] Dramatic increases in energy prices likely pushed more people into energy poverty.

Figure 1: Household fuel prices 2020 - 2023.



SEAI has a role in both informing and delivering energy poverty policy. One strand of Irish energy poverty policy involves reducing the amount of energy required to keep homes adequately warm through improving their energy efficiency.[6]

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[1] Barrett, M., Farrell, N. & Roantree, B. (2022). Energy Poverty and Deprivation. ESRI Research Series Number 114. https://www.esri.ie/publications/energy-poverty-and-deprivation-in-ireland

[2] Department of the Environment, Climate and Communications (2022). Energy Poverty Action Plan.

[3] Lawlor, D. & Visser, A. (2022). Energy Poverty in Ireland. *Oireachtas Library & Research Service.* https://data.oireachtas.ie/ie/oireachtas/libraryResearch/2022/2022-03-04_l-rs-note-energy-poverty-in-ireland_en.pdf

[4] Energy poverty is defined by the EU Energy Efficiency Directive as a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes.

[5] SEAI Energy Price Statistics. https://www.seai.ie/data-and-insights/seai-statistics/prices/

[6] Dingley, O. (2023). Addressing Energy Poverty in Ireland. Geary Institute for Public Policy.

SEAI administers state-funded grants to alleviate some of the financial burden associated with these upgrades, with the Warmer Homes Scheme targeting some of those without the means to upgrade their home themselves.[7] SEAI also conducts research and provides advice to the Irish government to inform policy design. In 2022, the Irish government launched the "Reduce Your Use" campaign to educate and encourage citizens and businesses to use less energy. SEAI's Behavioural Economics Unit played a supporting role in this campaign by designing the Behavioural Energy and Travel Tracker (BETT), from which the analysis presented in this report draws (see box below).

Ireland's Behavioural Energy and Travel Tracker

The Behavioural Energy and Travel Tracker (BETT) is a nationally representative online survey designed by SEAI's Behavioural Economics Unit. The tracker uses a behavioural science technique known as the "Day Reconstruction Method" to gather accurate and granular data about travel and home energy behaviours in Ireland. It also collects data on factors that may be related to energy behaviours, such as psychological factors, energy poverty, and dwelling and sociodemographic characteristics. BETT ran monthly from December 2022 to December 2023 and continues to run on a quarterly basis.

1.1.1. Scope of this report

BETT has generated a rich dataset that is being used to explore research questions in a number of different areas related to energy behaviour. Here, we make use of several unique aspects of this data to address gaps in the existing evidence base around energy poverty, including the simultaneous collection of different energy poverty indicators alongside energy behaviours at different times in the year.

This report uses monthly data generated by BETT between January and December 2023 to investigate research questions regarding the characteristics of the energy poor, seasonal variations in energy poverty, and the relationship between energy poverty and home energy behaviours.

1.2. Motivation and research questions

1.2.1. Energy poverty measures

To track the prevalence of energy poverty and design policies to target those in energy poverty it is first necessary to choose an energy poverty measure. Common measures include expenditure-based, subjective, and objective measures, but all have their benefits and drawbacks and there is no consensus on a single best measure.

Boardman's 10% threshold is the main expenditure measure used in Ireland, determining a household to be in energy poverty if their energy costs (electricity and heating) are more than 10% of their disposable income.[3,8] The appeal of this indicator is how easily calculated and understood it is, but it is imprecise.[9,10] The measure includes higher income households spending a large proportion of their income on energy but who can afford to do so comfortably, and excludes those who are inadequately heating their homes due to underconsumption to manage their expenses.[11,12]

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[7] SEAI Fully Funded Energy Upgrades. https://www.seai.ie/grants/home-energy-grants/fully-funded-upgrades-for-eligible-homes/

[8] Boardman, B. (1993). Opportunities and constraints posed by fuel poverty on policies to reduce the greenhouse effect in Britain. Applied Energy. Vol. 44(2), pp:185-195. https://doi.org/10.1016/0306-2619(93)90061-S

[9] Liddell, C., Morris, C., McKenzie, S.J.P., Rae, G. (2012). Measuring and monitoring fuel poverty in the UK: National and regional perspectives. Energy Policy. Vol. 49, pp:27-32. https://doi.org/10.1016/j.enpol.2012.02.029

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[11] Romero, J. C., Linares, P. & López, X. (2018). The policy implications of energy poverty indicators. Energy Policy. Vol. 115. https://doi.org/10.1016/j.enpol.2017.12.054

[12] Schuessler, R. (2014). Energy poverty indicators: Conceptual issues – Part I: The Ten-Percent-Rule and Double Median/Mean Indicators. ZEW – Centre for European Economic Research Discussion Paper No. 14-037.

Subjective measures rely on self-reported survey data, asking about a household's relative experiences of indicators related to poverty.[13] These measures are more inclusive, and acknowledge the reality of someone experiencing energy deprivation, however their subjectivity can be problematic.[14] For example, the Survey on Income and Living Conditions (SILC) asks whether participants can keep their house adequately warm,[15] but what is adequate for one person may be thought inadequate by another.

Objective measures consider household income, energy efficiency of the home, and the costs associated with heating the home to a "basic standard" as determined by the World Health Organisation (WHO).[14] Objective measures require more data to calculate, including dwelling temperature measures, the energy rating of the home, and fuel tariff data. The term "objective" lends an authority to these kinds of metrics that may be unwarranted. The UK's Low Income Low Energy Efficiency (LILEE) method considers energy poverty to be solely comprised of income and energy efficiency of the home, which stabilises energy poverty numbers in comparison to expenditure and subjective measures by concealing the impact of energy prices.[13] The additional data required for these measures make it expensive to collect, and there is a lack of consideration of different "basic standards" for different groups, for example, the medically vulnerable.

It is not clear how different measures of energy poverty relate to each other in Ireland and which should be used in what contexts. Research in France and Britain has highlighted that in some contexts different energy poverty measures have little overlap and are associated with different socio-economic characteristics, reflecting the multi-dimensionality of energy poverty.[16,17] Therefore, using only one or two measures of energy poverty may exclude some vulnerable people.[16,18] BETT affords us the opportunity to use one dataset (avoiding methodological differences that limit comparability) to observe the interaction of different energy poverty measures in Ireland.

Delivering targeted policy requires identifying those who are vulnerable to experiencing energy poverty. Existing targeted energy poverty supports in Ireland typically focus on lower-income households who live in energy-inefficient dwellings and are of retirement age.[19] However, two in five Irish households that report experiencing energy poverty are not eligible for support under current policy criteria.[19,22] There is room for improvement in targeted energy poverty policy coverage. British and Irish research has shown that disability, tenure status, education, gender, household composition, and employment status can all influence vulnerability to deprivation in terms of either high energy expenditure or low energy consumption.[20,21] Dwelling characteristics, such as dwelling type, energy efficiency, and condition have also been identified in the literature as predictive of energy poverty vulnerability,[10,20,22] as have factors like the gas supplier switching rate.[22]

BETT collects information on sociodemographic and dwelling characteristics as well as multiple measures of energy poverty from the same sample, allowing us to investigate the characteristics of the energy poor using different measures. We can thus investigate how different energy poverty measures overlap to make recommendations for targeting energy poverty supports to those who need them. Our first research question is as follows:

RQ1: What are the characteristics of the energy poor and are they different depending on the measure used?

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[13] Middlemiss, L. (2017). A critical analysis of the new politics of fuel poverty in England. Critical Social Policy. Vol. 37, pp:425–443. https://doi.org/10.1177/0261018316674851

[14] Herroro, S.T. (2017). Energy poverty indicators: A critical review of methods. Indoor and Built Environment. Vol. 26(7). https://doi.org/10.1177/1420326X17718054

[15] CSO Survey on Income and Living Conditions. https://www.cso.ie/en/statistics/socialconditions/surveyonincomeandlivingconditionssilc/

[16] Legendre, B. & Ricci, O. (2015). Measuring fuel poverty in France: Which households are the most fuel vulnerable? Energy Economics. Vol. 49, pp:620-628. https://doi.org/10.1016/j.eneco.2015.01.022

[17] Deller, D., Turner, G. & Waddams Price, C. (2021). Energy poverty indicators: inconsistencies, implications and where next? Energy Economics. Vol. 103. https://doi.org/10.1016/j.eneco.2021.105551

[18] Castaño-Rosa, R., Solís-Guzmán, J., Rubio-Bellido, C. & Marrero, M. (2019). Towards a multiple-indicator approach to energy poverty in the European Union: A review. Energy and Buildings. Vol. 193, pp:36-48. https://doi.org/10.1016/j.enbuild.2019.03.039

[19] Pillai, A., Tovar-Reaños, M. A. & Curtis, J. (2023). Keep out the cold: An analysis of potential gaps in fuel poverty policies in Ireland. Energy Research & Social Science. Vol. 98. https://doi.org/10.1016/j.erss.2023.103012

[20] Insight Energy (2015). Energy poverty and vulnerable consumers in the energy sector across the EU: analysis of policies and measures.

[21] Fahmy, E., Gordon, D. & Patsios, D. (2011). Predicting fuel poverty at a small-area level in England. Energy Policy. Vol. 39(7), pp:4379-4377. https://doi.org/10.1016/j.enpol.2011.04.057

[22] Spandangos, C., Tovar- Reaños, M. A. & Lynch, M. Á. (2023). Energy poverty prediction and effective targeting for just transitions with machine learning. *ESRI Working Paper No. 762.* *https://www.esri.ie/system/files/publications/WP762_1.pdf*

1.2.2. Seasonality in energy poverty

Given the seasonality in household energy expenses, it is reasonable to expect there may be seasonal fluctuations in people's experience of energy poverty, but this has received little attention to date.[23] The two main measures of energy poverty used in Ireland are expenditure-based and subjective measures derived from the Household Budget Survey (HBS) and SILC, respectively. Neither of these energy poverty metrics account for any seasonal trends in energy poverty. SILC data collection occurs once per year, and HBS data collection is conducted at multiple points in time but is aggregated at the annual level.

BETT was run on a monthly basis in 2023. This allows us to track energy poverty levels across time and identify any seasonal trends. Our second research question is as follows:

RQ2: Does energy poverty fluctuate depending on the time of year?

1.2.3. Relationship between energy poverty and energy behaviour

The underlying logic of including occupant behaviour in the conceptualisation of energy poverty is that encouraging energy conserving behaviours can provide cost savings, and this would positively impact vulnerable consumers.[24,25] Heating behaviour is particularly of interest, as it is the most energy intensive behaviour carried out in the home, and many conceptions of energy poverty centre around the ability to adequately heat the home.[26]

On the one hand, people on lower incomes are more likely to have a lower educational attainment and may be time poor, have less awareness of or less mental space to consider how to save energy at home, or engage in energy intensive behaviours excessively that may exacerbate their energy poverty. On the other, people in energy poverty may be particularly aware of energy costs, and potentially consuming less energy than they should to maintain a good standard of living.[27,28]

Understanding the behaviours of those in energy poverty can allow us to better understand its dynamics. If a person in energy poverty is consuming energy inefficiently, there may conceivably be some scope to help mitigate their deprivation by encouraging energy conserving behaviours. Moreover, if they are under-consuming energy to mitigate their financial burden, the incidence of energy poverty according to the expenditure measure may fall, but these people are still experiencing hidden energy deprivation.[10] Our third main research question is as follows:

RQ3: Is being in energy poverty associated with any differences in energy behaviour?

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[23] Sareen, S., Thomson, H., Tirado Herrero, S., Gouveia, J.P., Lippert, I. & Lis, A. (2020) European energy poverty metrics: Scales, prospects, and limits. Global Transitions. Vol 2, pp:26-36. https://doi.org/10.1016/j.glt.2020.01.003

[24] DellaValle, N. (2019). People's decisions matter: understanding and addressing energy poverty with behavioural economics. *Energy and Buildings.* Vol 204. https://doi.org/10.1016/j.enbuild.2019.109515

[25] Kearns, A., Whitley, E. & Curl, A. (2019). Occupant behaviour as a fourth driver of fuel poverty (aka warmth & energy deprivation). *Energy Policy.* Vol. 129, pp. 1143-1155. https://doi.org/10.1016/j.enpol.2019.03.023

[26] Simcock, N., Walker, G. & Day, R. (2016). Conceptualising energy use and energy poverty using a capabilities framework. *Energy Policy 93, pp. 255-264.* https://doi.org/10.1016/j.enpol.2016.03.019

[27] Simcock, N., Walker, G. & Day, R. (2016). Fuel poverty in the UK: beyond heating? *People, Place and Policy.* Vol. 10(1), pp: 25-41. https://doi.org/10.3351/ppp.0010.0001.0003

[28] Middlemiss, L. & Gillard, R. (2014). Fuel poverty from the bottom-up: Characterising household energy vulnerability through the lived experience of the fuel poor. *Energy Research & Social Science.* Vol. 6, pp: 146-154. https://doi.org/10.1016/j.erss.2015.02.001

2. Methodology

2.1. Sampling and data collection

We use data from Ireland's Behavioural Energy and Travel Tracker (BETT) survey. The survey is ongoing, but the data used for this analysis were collected monthly from January through December 2023 (12 waves). Each wave was run online with a sample of 1,000 participants, recruited by a market research company, that was approximately representative of the Irish population in terms of gender, age, geographical region, and social grade, resulting in a total sample size of n=12,000. Participants could partake in multiple waves, but not consecutive waves. Participants were paid €4 and typically took about 15-20 minutes to complete the survey.

2.2. Survey design

A full description of BETT and details of individual, household, and dwelling characteristics of the sample are available elsewhere.[29] Here we briefly summarise the parts of BETT directly relevant to the analysis presented in this report.

2.2.1. Day reconstruction and energy behaviour

BETT adapts the Day Reconstruction Method (DRM) to measure energy behaviours performed on a given day (the day preceding data collection). Participants are first prompted to think through the previous day and make a note of any energy-related behaviours. We do not analyse these responses – they serve only to improve recall for subsequent parts of the survey. Following this, they respond to detailed questions about heating, hot water use, cooking and electrical appliance use, with branching used to ensure participants only answer questions that are relevant to them.

2.2.2 Additional variables

Once participants have completed the day reconstruction task, we collect data on a range of other factors that might be related to their behaviour and measures related to energy deprivation. If the participant is responsible for paying energy bills, we ask them how much their household spent on motor fuel, electricity, and central heating (all to the nearest €25), as well as secondary heating fuels (to the nearest €10) in the previous month.[30]

We also take subjective measures of energy poverty by asking participants how difficult it was to pay their most recent home energy bill, whether they have had to go without heating in the past month through lack of money, and whether they have had to cut back on other essentials, miss other payments or borrow money to pay their home energy bills in the past month.

The survey concludes with a range of standard sociodemographic questions and questions about the participants dwelling and household. We ask all participants to disclose their monthly household net income (to the nearest €250), but this question is not mandatory.

[29] SEAI (2023) Behavioural Energy and Travel Tracker: Results report 1 – heating season 2022/2023. https://www.seai.ie/data-and-insights/behavioural-insights/publications/behavioural-energy-and-tr/

[30] If the participant has bi-monthly bills, we ask them to divide their last bill in two.

2.3. Variables of interest and analysis approach

2.3.1 Energy poverty measures

We create four binary variables denoting whether a participant is in energy poverty according to different measures. Three are based on subjective measures of energy poverty collected directly from the survey and the fourth is an expenditure measure constructed from participants reported home energy costs and household income, for those that report these.[31] Our indicators are:

1. Difficulty paying energy bills
2. Going without heating
3. Cutting back on essentials
4. Spending 10% of disposable income on energy costs

We describe these in more detail below.

We use logistic regression models to identify the factors that are related to whether someone is experiencing energy poverty, as defined by different measures outlined above. The factors we include in models are time of year, sociodemographic characteristics (age, gender, location, education, social grade, employment status, income, household composition, disability, and tenure) and dwelling characteristics (house type, heating system, and BER).[32]

To account for the time of year, we create a season variable, with June to September being "summer", December to March being "winter" and the months in between (October, November, April, and May) being the "shoulder months". The models reported in Appendix B include all independent variables mentioned above (one that controls for income and one that does not), but we ran equivalent additional models that excluded sociodemographic, and dwelling characteristics, respectively. We note any relevant differences throughout the text.

Difficulty paying energy bills

We ask participants who have some responsibility for paying bills how difficult it was to pay their most recent home energy bill and they choose from the following responses:

1. Not at all difficult
2. Found it expensive but no difficulty paying
3. Had some difficulty but paid on time
4. Unable to pay on time
5. Unable to pay at all
6. Not applicable

For analysis, we categorise participants who chose responses 3 to 6 as being in energy poverty. Those who had no difficulty paying or aren't responsible for paying bills were categorised as not experiencing energy poverty, and those who responded "Not applicable" were excluded from the analysis of this measure.

Going without heating

The second subjective measure we collect considers home heating. We ask billpaying participants whether they have had to go without heating through lack of money in the preceding month, and they choose from the following responses:

1. Yes – once
2. Yes – more than once
3. No

Participants who chose responses 1 or 2 were categorised as being in energy poverty according to this measure.

[31] To keep our expenditure energy poverty measure comparable with other sources and in line with the literature, we do not include motor fuel costs in our calculation.

[32] Participants who don't know their heating system or BER are included in the models but we do not report on their associations.

Cutting back on essentials

For our final subjective measure, we ask billpaying participants whether they have had to cut back on other essentials (such as food), miss other payments (such as rent or other bills) or borrow money in the past month in order to pay their home energy bills, and they choose from the following responses:

1. Yes – once
2. Yes – more than once
3. No

Participants who chose responses 1 or 2 were categorised as being in energy poverty according to this measure.

10% expenditure measure

We ask participants who are responsible for paying bills how much they spent on electricity, central heating, and other heating fuels in the preceding month. We also ask participants what their household's monthly net income is, although a response is not mandatory. From this, we construct an expenditure measure of energy poverty, in which billpayers that spend more than 10% of their household income on energy costs are in energy poverty. Participants who don't disclose their household's income and energy costs are excluded from analysis for this measure.

2.3.2 Energy behaviours

Inefficient energy behaviours

Previous analysis of BETT data has focused on identifying factors related to performing a range of "inefficient" behaviours. These are instances where it is likely that more energy is used than needed.[33] Here, we investigate the relationship between experiencing energy poverty and some of these behaviours:

1. Heating unoccupied rooms or home
2. Taking multiple showers or baths, or taking a long shower (over 10 mins) or full bath
3. Using energy intensive appliances (the oven, or the hob for longer than 15 mins) to cook a small number of portions (two or fewer)
4. Using a tumble dryer
5. Using a washing machine inefficiently
6. Using a dishwasher inefficiently

We identify participants heating empty space in two ways: through their response to a question asking whether they had the central heating on in any unoccupied rooms (excluding those that say they did so but at a lower temperature) and by identifying participants who said the heating was used at times of day when they had previously indicated no one was home. For appliances, we focus on the use of larger, more energy intensive appliances such as the washing machine, tumble dryer, and dishwasher. For washing machines and dishwashers, inefficient use was defined as not using eco settings, not filling the machine or, for washing machines, setting the temperature to 50°C or higher. Using the tumble dryer was designated as wasteful in and of itself.

To investigate the relationship between experiencing energy poverty and performing inefficient energy behaviours, we used logistic regression models, modelling each energy poverty measure with the inefficient behaviours. We control for season, sociodemographic factors, and dwelling characteristics.

Heating behaviour

We examine the relationship between energy poverty and different aspects of heating behaviour – use of primary and secondary heating, duration for which primary heating is used, and thermostat settings, again using logistic regression models and controlling for weather (heating degrees, rainfall, sunshine, windspeed) and temporal (heating season, day of week) variables. A more detailed description of heating behaviour in general and the analysis approach is available in a separate report.[34]

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[33] SEAI (2023) Behavioural Energy and Travel Tracker: Results report 1 – heating season 2022/2023. https://www.seai.ie/data-and-insights/behavioural-insights/publications/behavioural-energy-and-tr/

[34] SEAI (2024). Heating behaviour in Ireland: Analysis of 2023 data from the Behavioural Energy and Travel Tracker.

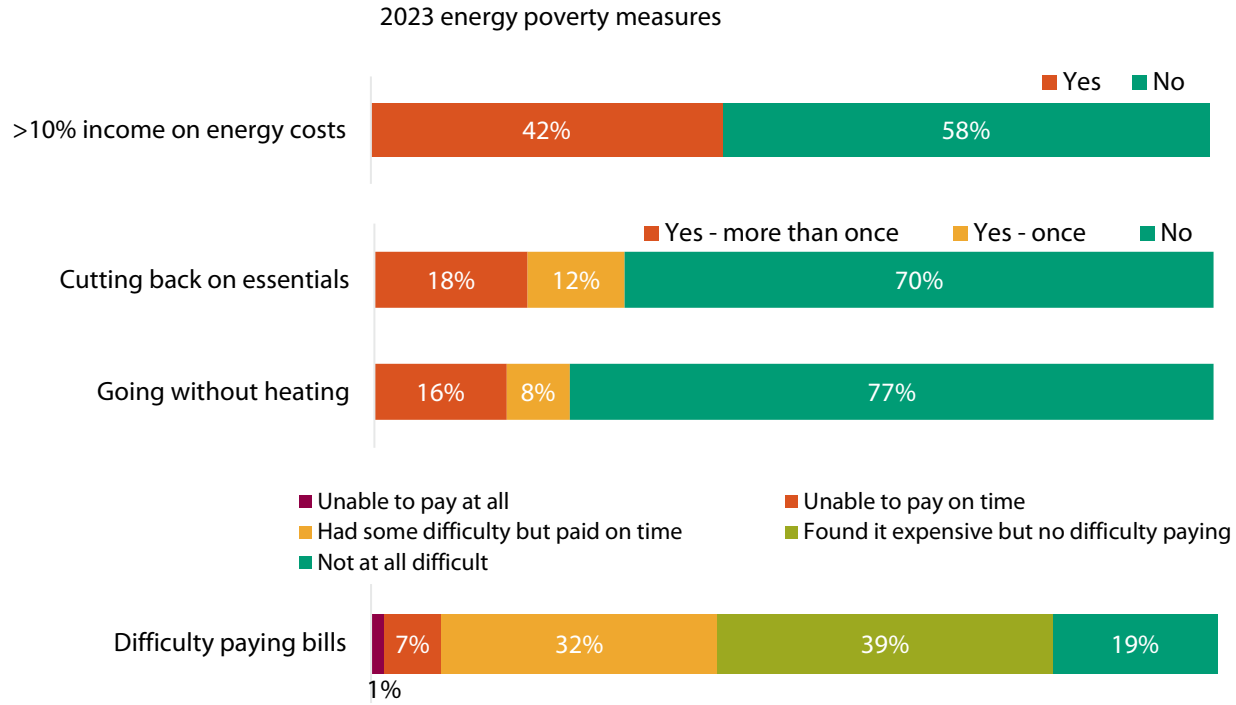
3. Results

We begin this section with an overview of the prevalence of energy poverty according to the four measures we track. We then examine the overlap between different energy poverty measures, the sociodemographic and dwelling characteristics associated with energy poverty, and the seasonality of different measures. We end this section by describing associations between energy poverty measures and energy behaviour.

3.1. Prevalence of energy poverty

Energy poverty was highly prevalent in Ireland in 2023, regardless of which measure is used to define it (see Figure 2). At the lowest rates in August and September, 53% of bill paying respondents (or 49% of the full sample) experienced energy poverty by at least one measure, rising to 67% of billpayers (62% of people) at the highest rates in March.

Figure 2: Mean proportion of participants spending 10% or more of their income on energy bills (of those who provided income and energy costs), and participants' responses to (a) whether they had, in the past month, cut back on other essentials (such as food), missed other payments (such as rent or other bills) or borrowed money in order to pay their home energy bills, (b) whether they had, in the past month, had to go without heating, and (c) how difficult they found it to pay their most recent energy bill (participants who responded "not applicable" (1%) not shown).



On average across the year, 42% of participants spent 10% or more of their disposable income on energy costs (of those that reported both income and energy costs – about four in five participants), and 17% spent 20% of their income or more, which is considered by some to represent extreme energy poverty.[3]

Three in ten billpayers reported having cut back on essentials to afford their energy bills, most of which did so multiple times in the previous month (Figure 2). Going without heating was the least commonly reported of our measures (although this is likely in part due to decreased relevance in the summer months), with 23% of bill paying participants having done so in the preceding month on average (rising to 26% during the heating season when outdoor temperatures are colder), and most doing so more than once.

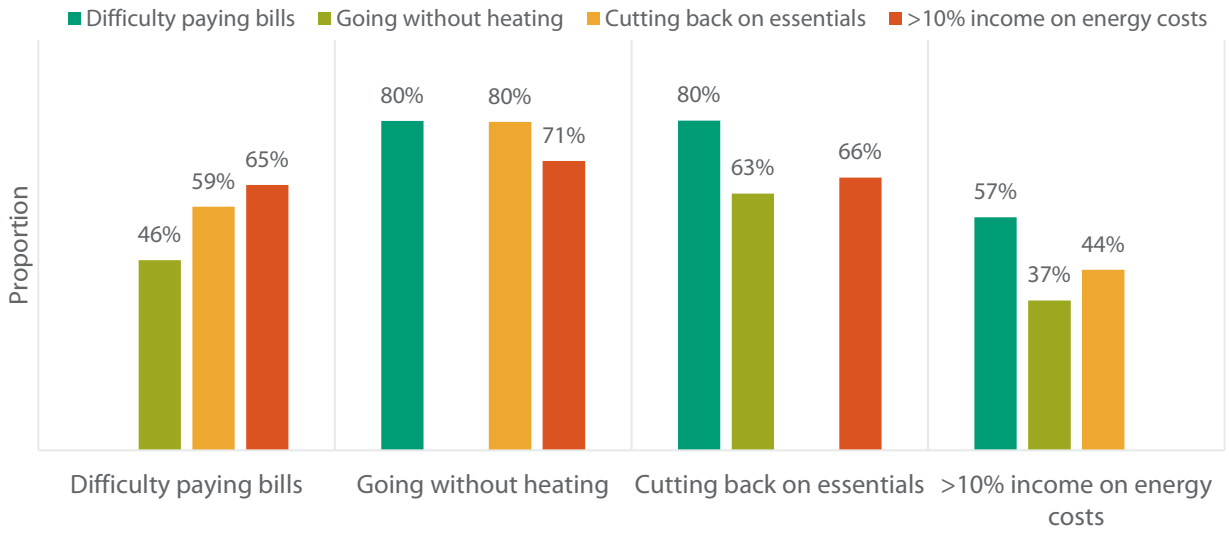
Two in five bill paying participants reported having difficulty paying their last energy bill, including 7% who were unable to pay on time and 1% who were unable to pay at all (Figure 2). About one in five had no difficulty paying their last energy bill, and the remaining two in five said they found it expensive but were able to pay without difficulty.

3.2. Overlap between different energy poverty measures

Of the participants who were experiencing energy poverty, more than two thirds were classified as such according to more than one measure. Figure 3 illustrates the interaction of different energy poverty measures.

Most participants (54%) who reported going without heating or cutting back on other essentials were in fact doing both and, interestingly, four in five people who reported going without heat or cutting back on essentials still reported having difficulty paying their bills. While there was considerable overlap between measures, one third of people spending 10% of their disposable income on energy did not self-report as being at risk of energy poverty according to any of our other three measures, and more than a quarter of those experiencing all three subjective measures were spending less than 10% of their income on energy costs. Nonetheless, 12% of participants who disclosed income and energy costs were experiencing energy poverty according to all of our measures.

Figure 3: The proportion of people who are (a) having difficulty paying bills, (b) going without heating, (c) cutting back on essentials, and (d) spending more than 10% of their income on energy costs, that are also experiencing energy poverty by each of the other measures.



3.3 Factors associated with energy poverty

We used logistic regression modelling to investigate which factors (time of year, sociodemographic and dwelling characteristics) were associated with each measure of energy poverty. We ran two models for each measure, one that did not control for income and one that did. Models in Appendix B contain all independent variables, but we also modelled sociodemographic and dwelling variables separately and note any relevant differences. We first report the characteristics of the energy poor without controlling for income to identify groups that can be used for targeting that is not income-based, and then note which effects change when income is accounted for.

3.3.1 Sociodemographic characteristics

Table 1 presents a visual summary of regression model results (see Appendix A for sociodemographic and dwelling characteristics of people in energy poverty and Appendix B for full model outputs).

Table 1: Summary table of logistic regression results showing the relationship between different measures of energy poverty and sociodemographic characteristics, while controlling for dwelling characteristics.

	Difficulty paying bills	Going without heating	Cutting back on essentials	>10% income on energy
Male	−	−	−	−
Older age	−	−	−	+
Lower social grade	+	+	+	+
Degree	−	−	−	−
Employment	−	−	−	
Urban area	−		−	−
Couple (vs. alone)	−	−	−	−
Family (vs. alone)	+	−		−
Disability in home	+	+	+	+
Renter	+	+	+	+

+ positive relationship; − negative relationship

The sociodemographic characteristics associated with being in energy poverty were not the same for each of the measures tracked. When not controlling for income, people living rurally were more likely to be spending over 10% of income on energy costs, cutting back on essentials and having difficulty paying bills compared to those in urban areas, but there was no relationship with living in a rural location and going without heating. Families were less likely to go without heating or spend over 10% of their income on energy bills compared to people living alone but were more likely to have difficulty paying bills. People not in employment and younger people (under 35) were more likely to report going without heating and cutting back on essentials compared to employed people and older groups, respectively. However, people aged over 55 were more likely to be spending 10% of their income on energy costs, and there were no employment status effects for this measure.

We disaggregated our age categories further to get a better picture of the rates at which different cohorts were experiencing energy poverty.[35] The percentage of people aged over 65 who reported being in energy poverty was lower than those aged under 65. The contrast is most apparent for our subjective measures of energy poverty, with 23% of over 65s reporting difficulty paying bills (vs 40% of under 65s), 11% going without heating (vs 24% of under 65s), and 12% cutting back on essentials (vs 31% of under 65s).

[35] From three age brackets (under 35, 35-54, and 55+) to six (18-24, 25-34, 35-44, 45-54, 55-64, and 65+).

While some of the characteristics of the energy poor were different depending on the measure used, others were more consistent. Women, renters, people belonging to lower social grades, educated to below degree level, living alone (in comparison to those living as a couple), and living in a household in which someone has a disability were more likely to experience all four types of energy poverty we measure. These same groups were also more likely to report experiencing energy poverty according to all three subjective measures simultaneously, with the addition of under 35s (in comparison to over 55s) and people not in employment (Appendix B).

It is important to note that when household income is included in the models, it has the strongest association with all three measures of energy poverty, and some other associations are accounted for or changed. Excluding income from the model, people in rural areas were more likely to be spending 10% or more of their income on energy costs but when we control for income, this is no longer the case. When income is included in the model, household composition had mixed associations with energy poverty. Without controlling for income, couples were less likely to experience energy poverty by any measure than people living alone, but when we include income, this association only persists for cutting back on essentials, and couples were more likely to spend 10% of their income on energy costs. When income is included in the model, the size of some effects (like gender, education, disability in the household, and tenure) are reduced, but not eliminated.

3.3.2 Dwelling characteristics

Table 2 summarises the relationship between dwelling characteristics and the four measures of energy poverty tracked.

Table 2: Summary table of logistic regression results showing the relationship between energy poverty using four different measures and dwelling characteristics, while controlling for sociodemographic characteristics.

		Difficulty paying bills	Going without heating	Cutting back on essentials	>10% income on energy
Ref: Detached	Apartment		−	−	−
	Semi-D			−	
	Terraced		+	+	
Ref: A/B/C1 BER	C2/C3/D	+	+	+	+
	E/F/G/Exempt	+	+	+	
Ref: Oil boiler	Electric				+
	Gas boiler				+
	Heat pump/district heating		−		
	Solid fuel				
	None	−			−

+ positive relationship; − negative relationship

The relationship between energy poverty and dwelling characteristics also differed depending on the measure used. Living in a home with a BER of C2 or lower was associated with having difficulty paying bills, going without heating, and cutting back on essentials, but those living in the poorest rated homes (E1-G) were not significantly more likely to be spending 10% of their income on energy costs compared to those in the highest rated homes. Those living in detached houses were less likely to report going without heating in the previous month and cutting back on essentials than people in terraced houses, but more likely to do so than those living in apartments. People with electric boilers, storage heaters or gas boilers were more likely to spend 10% of their income on energy costs compared to those using oil central heating, but there was no association with other measures of energy poverty.

Dwelling characteristics associated with energy poverty were mostly unaffected by controlling for income in the models. The only change was for BER – when we didn't control for income, living in a C2/C3/D rated home was associated with energy poverty by all measures, but when income is included the association with spending 10% or more of household income on energy costs becomes non-significant.

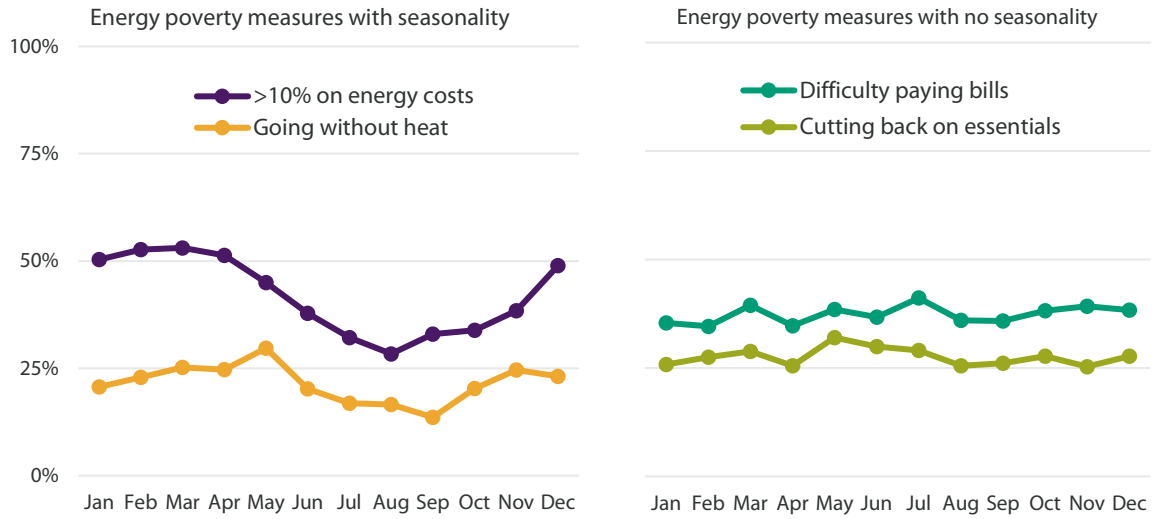
3.4 Seasonality in energy poverty

To test for seasonal variations in energy poverty we included a "season" variable in our models, with June to September being "summer", December to March being "winter" and the months in between (October, November, April, and May) being the "shoulder months".

We find seasonal trends in the proportion of participants spending over 10% of disposable income on energy bills and the proportion going without heating in the previous month (Figure 4). Expenditure-based energy poverty peaks in March, with just over half of participants spending 10% of their income on energy costs and falls to its lowest in August to just under three in ten participants. The proportion reporting going without heating, on the other hand, appears to peak in the shoulder months at either end of the heating season, with 30% of people in May reporting they had gone without heating in the previous month. The proportion of people going without heating in the previous month falls to its lowest in September, at 14%.

The proportion of participants reporting difficulty paying bills and cutting back on essentials were much more stable across the year.

Figure 4: Proportion of participants experiencing energy poverty according to different measures by month. The expenditure measure is the proportion of participants spending 10% or more of their disposable income on energy costs of those who reported both income and energy costs.



3.5 Energy poverty and behaviour

3.5.1 Inefficient behaviours

Table 3 summarises the results of regression models (Appendix B) investigating the relationship between performing inefficient energy behaviours and experiencing energy poverty, as defined by different measures. We did find associations between experiencing energy poverty and performing some of the inefficient behaviours defined. Participants experiencing energy poverty were more likely to use hot water inefficiently and use a tumble dryer regardless of which measure was used. Inefficient washing machine use was also associated with our subjective measures only.

However, a different pattern was seen for inefficient behaviour related to heating – the most energy intensive behaviour we track. Participants who reported going without heating or cutting back on essentials were less likely to have heated unoccupied rooms or an unoccupied home, but those who spent 10% or more of their income on energy were more likely to have done so.

Table 3: Summary table of logistic regression results showing the relationship between energy poverty using four different measures and performing different inefficient behaviours, while controlling for sociodemographic and dwelling characteristics.

Inefficient behaviour	Difficulty paying bills	Going without heating	Cutting back on essentials	>10% income on energy
Heating unoccupied rooms/home		−	−	+
Inefficient hot water use	+	+	+	+
Cooking inefficiently				
Inefficient washing machine use	+	+	+	
Tumble dryer	+	+	+	+
Inefficient dishwasher use		−		

+ positive relationship; − negative relationship

3.5.2 Home heating

To examine the relationship between energy poverty and heating behaviour, we look both at the duration for which heating was used and thermostat settings (where a participant owns a thermostat).

Heating use and duration

Figure 5 shows the duration for which heating was used, specifically during the heating season, according to whether a participant was experiencing energy poverty by each of the four different measures. Duration is shown separately for primary heating (central and underfloor heating) and secondary heating (open fires, stoves and portable heaters).

We see different relationships between heating behaviour and energy poverty depending on the measure used. When subjective energy poverty measures are used, we generally find that those experiencing energy poverty heat their homes for less time. This is particularly true of those who self-report as having gone without heat; people in this group heat their homes for a full hour less than the rest of the sample on average. However, those experiencing energy poverty according to the 10% expenditure metric in fact heat their homes for longer than those spending a smaller proportion.

Figure 5: Mean number of hours for which primary and secondary heating sources were used in a given day during heating season months (October to May), for each of the four measures. Where a participant was not home on the reference day or did not use a given heating type, a duration of 0 h was assigned.

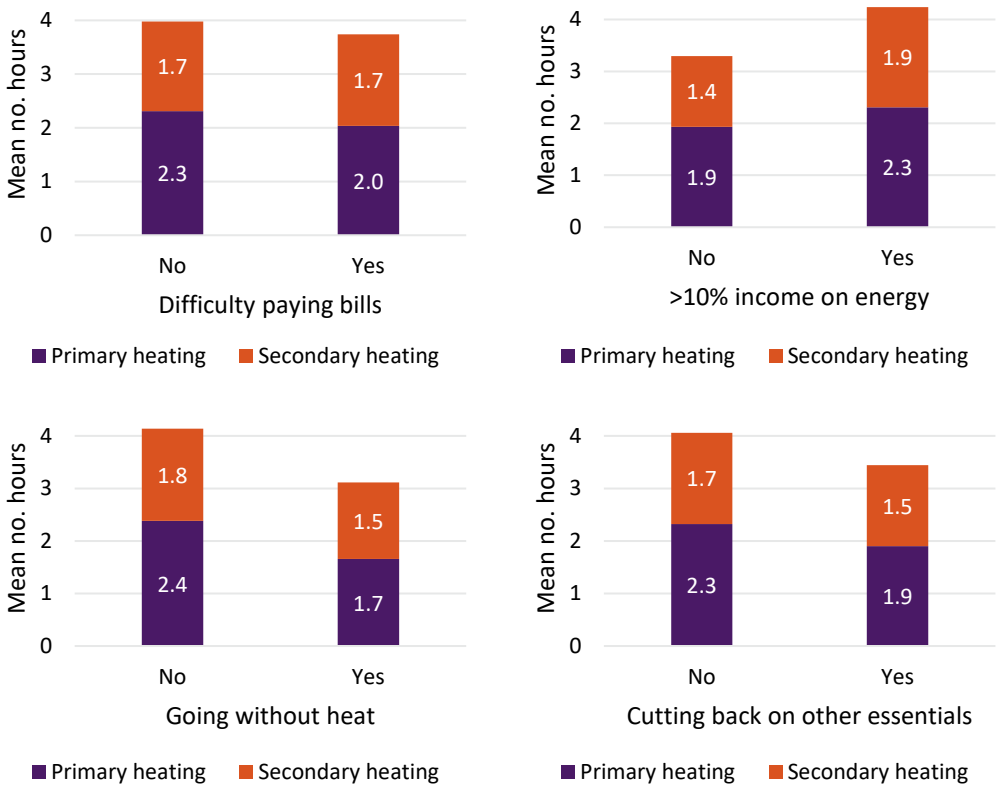


Table 4 summarises the results from logistic regression models looking at the link between energy poverty measures and heating behaviour when controlling for weather conditions, time of year (heating season vs. other months) and day of week (weekend vs. weekday) (full model results can be found in Appendix B).

Those who reported going without heat or cutting back on other essentials were less likely to use primary heating in a given day than those who didn't (assuming they were home on that day), although they were no less likely to use secondary heating. There was no relationship between having difficulty paying bills and using heating, but spending over 10% of income on energy was associated with a higher likelihood of using both primary and secondary heating.

A similar pattern is seen when looking at the duration for which primary heating was used (if it was used at all). Those who reported going without heat or cutting back on other essentials were less likely to heat for longer times (whether using a two hour or four hour cut off). There was a weaker relationship with difficulty paying bills, although heating for extended periods (over four hours) was less prevalent in this group. Participants who spent over 10% of their income on energy, on the other hand, were significantly more likely to use heating for longer times. This effect persists when controlling for dwelling and household characteristics that might affect need for heat (dwelling type, BER rating, heating type, thermostat, presence of under 18s, over 65s or disability in the household).

Table 4: Summary table of logistic regression results showing the relationship between energy poverty using four different measures and (a) using primary heating at all, (b) using primary heating for long durations, and (c) setting the thermostat to a high temperature in a given day if a participant was home on that day, while controlling for weather, time of year, and whether the reference day fell on a weekend.

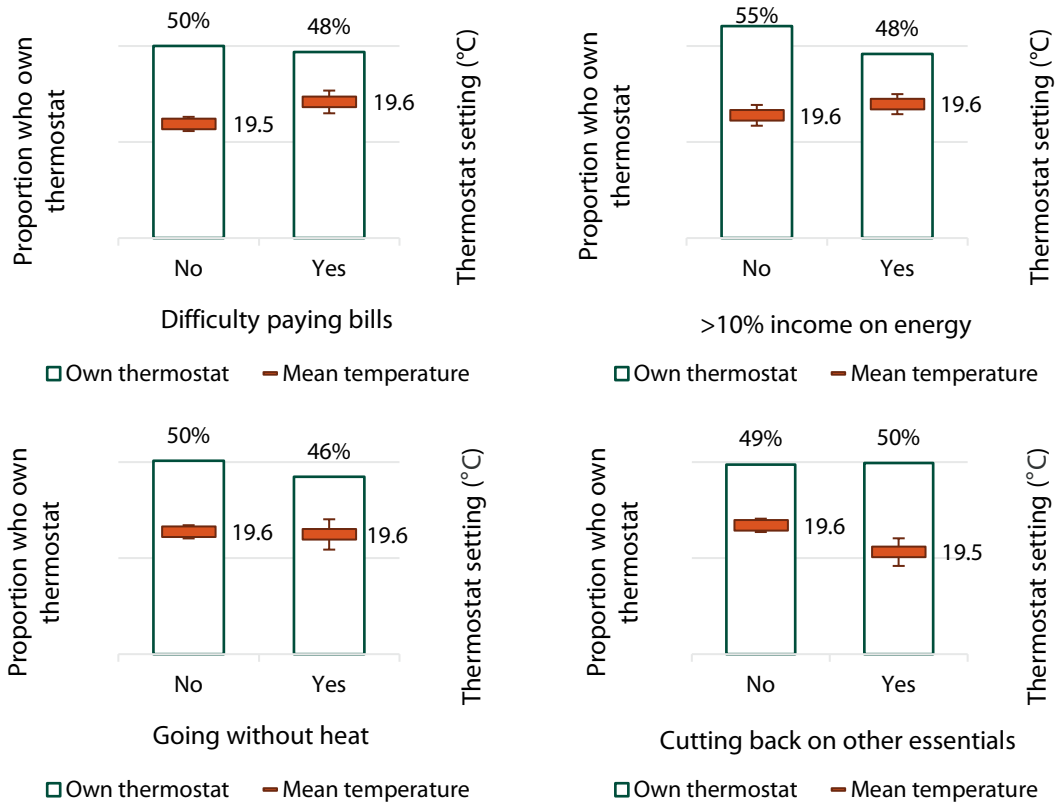
	Difficulty paying bills	Going without heat	Cutting back on essentials	>10% income on energy
Use of heating		−	−	+
Primary heating duration	−	−	−	+
Higher thermostat setting			−	

+ positive relationship; − negative relationship

Thermostat settings

Figure 6 shows thermostat ownership and settings used, according to whether a participant was experiencing different types of energy poverty. About half of Irish households do not have a thermostat, so the results regarding thermostat settings pertain to a smaller sample, but the effects of energy poverty are less pronounced here than with heating duration.

Figure 6: Mean thermostat setting used by thermostat owners (if they used central heating on the reference day), split by whether or not a participant was experiencing energy poverty according to different measures. Error bars represent the standard error of the mean.



The only measure of energy poverty for which a relationship was seen with thermostat settings was cutting back on other essentials – those who reported doing so had their thermostats set very slightly lower (0.1°C on average) than those who didn't. Regression model results reveal this was due to these participants being more likely to use low settings of 18°C or under, but they were no less likely to use high settings of 21°C or higher. Notably, those who reported going without heat did not report using significantly lower thermostat settings.

4. Discussion

In this section we discuss the main findings arising from our analysis and make recommendations regarding both the measurement of energy poverty and the targeting of policies to address it.

4.1. Characteristics of the energy poor and targeting policy

While some of the sociodemographic and dwelling characteristics associated with experiencing energy poverty changed depending on the measure, other characteristics were consistently associated with being in energy poverty. Below we list the characteristics associated with experiencing energy poverty according to all three subjective measures from largest to smallest association (approximately):

1. Low income
2. Being aged under 35
3. Living in a household in which someone has a disability
4. Renting
5. Belonging to C2DEF social grades
6. Being educated to below degree level
7. Not being employed[36]
8. Living in a home with a BER of C2 or lower
9. Being a woman

Irish energy poverty policy focuses on improving energy efficiency to reduce energy demand, introducing consumer protection measures, and supplying some income supports.[2,6] However, few policies involve targeted delivery. Those that do, like the Warmer Homes Scheme and the Household Benefits Package, target older people (over 65s), and householders in receipt of certain social welfare payments or who have a disability. Other income supports are untargeted payments, like the electricity credits applied to all domestic customers from 2022-2025.

Our results point to several other streams by which supports could be targeted. For example, the minority of state energy grants are accessible to those on low incomes or suitable for renters, two of the groups most likely to be in energy poverty according to the measures we used. Currently, renters in the financial position to pay for an upgrade face two issues: having their landlord agree to the work, and the risk associated with investing in a dwelling they don't own. Landlords are eligible for retrofitting grants, but have little incentive to upgrade the home as they don't stand to experience any short-term benefit from the upgrade, exhibited by landlords making up only 2.6% of grant applicants between 2013-2018.[37] Legislation mandating minimum energy efficiency standards in the private rental sector could help. This policy measure has been under consideration by government over the last 9 years, first referenced in the Strategy to Combat Energy Poverty in 2016[38] and committed to in the 2021 Housing for All plan.[39]

Perhaps surprisingly, we did not find a positive association between older age and energy poverty, despite older people being one of the few groups targeted by energy poverty policy. In fact, we found over 55s were less likely to report having difficulty paying bills, going without heating, or cutting back than the under 35s, and over 65s reported being in energy poverty in lower proportions across the board than the rest of the sample. This may suggest that treating all older people as vulnerable to energy deprivation may not be appropriate, or that targeted supports for older people are having the desired effect. However, while we do draw on a nationally representative sample in terms of broad age categories (with the highest category being 65+), the fact BETT is an online survey means some computer literacy is required. Therefore, our participants aged over 65 may not be much older than 65, which might mean we aren't capturing the most elderly people in Ireland, who may be more at risk.

[36] This includes people who are unemployed, homemakers, caring for family members, in retirement, unable to work, and students.
[37] Threshold (2024). Submission to the Revised Energy Poverty Action Plan.
[38] Department of Communications, Energy, Natural Resources (2016). A strategy to combat energy poverty – 2016-2019.
[39] Department of Environment, Climate and Communications (2021). Housing for All – a New Housing Plan for Ireland.

4.2. Relationship between different energy poverty measures

Most of the energy poor population are experiencing energy poverty according to more than one measure. Intuition might lead us to assume that people cutting back make a choice between going without heating or cutting back on other essentials. However, most people who reported going without heating or cutting back on essentials were doing both. Further, most people who reported cutting back on essentials or going without heating still struggled to pay their bills. This highlights that for many, making significant sacrifices to basic needs does not fully alleviate energy poverty.

Some of the characteristics of the energy poor change depending on the measure used. This may reflect that different groups manage deprivation in line with their preferences and ability to cut back. For example, we found families were less likely to go without heating, but more likely to have difficulty paying bills and spend 10% of their income on energy costs. Nearly one in ten participants who were experiencing energy poverty were underheating their home and spending less than 10% of their income on energy costs. This is particularly an issue given the expenditure measure is the main energy poverty measure in Ireland. While most participants who experience energy poverty at all are experiencing energy poverty by multiple measures, choosing to use only one measure will exclude a significant proportion of people who are experiencing deprivation.

One third of participants who experienced expenditure energy poverty did not report cutting back or struggling to pay bills. This supports literature that suggests the expenditure measure is an imprecise one that tends to include participants who can comfortably spend high proportions of their income on energy costs and are not experiencing actual deprivation.[9,10,12]

4.3. Seasonality in energy poverty

To our knowledge, our analysis is the first to measure a seasonal trend in two energy poverty measures: the 10% expenditure measure and going without heating.[40] This has important implications for measuring energy poverty when using self-reported or subjective measures. Recency bias, which causes individuals to weigh their recent experience more heavily than past experience,[41] may lead people to give responses based on their experience at the current time, even if asked to reflect on their experience over the preceding 12 months, as energy poverty questions typically do. For instance, respondents may respond differently to a question about having gone without heating in the preceding year if asked in the summer compared with winter or the shoulder months. Those measuring energy poverty should consider collecting data at multiple points in the year, and bear in mind the limitations of figures collected at one point in time.

While two of our energy poverty measures showed seasonal trends, having difficulty paying bills and cutting back on essentials did not. This reflects that the burden of some aspects of energy poverty is high year-round.

4.4. Energy poverty and behaviour

4.4.1. Inefficient energy behaviours

There were some relationships between measures of energy poverty and inefficient home behaviours. Less energy intensive behaviours like using the tumble dryer and inefficient hot water use were associated with all four measures of energy poverty we used. These associations indicate there may be some potential for education to reduce energy bills for those in energy poverty through curbing hot water and tumble dryer use. However, there may be other factors besides lack of knowledge that are causing people in energy poverty to engage in these behaviours (e.g. a lack of space of air drying clothes or a simple lack of time and mental space).

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[40] One Japanese study identified seasonal differences in the 10% expenditure measure by comparing its incidence in February and August. Castaño-Rosa, R. & Okushima, S. (2021). Prevalence of energy poverty in Japan: A comprehensive analysis of energy poverty vulnerabilities. *Renewable and Sustainable Energy Reviews.* Vol. 145. https://doi.org/10.1016/j.rser.2021.111006

[41] Arni, F., Narsa, I. M., & Tjahjadi, B. (2020). Are emotions exacerbating the recency bias? An experimental study. *International Journal of Trade and Global Markets. 13(1).* https://doi.org/10.1504/IJTGM.2020.104913

It is also important to note that people are not experiencing energy poverty solely as a result of performing a few inefficient behaviours, so while encouraging energy conserving behaviours can help alleviate some of the burden, it is not a viable tool for reducing energy poverty.

4.4.2. Heating behaviour

There were significant differences in heating behaviour between those experiencing energy poverty and those who aren't. People who reported cutting back on essentials or going without heating in the previous month were less likely to heat their homes at all, and when they did, heated their homes for shorter periods of time. These findings legitimise subjective energy poverty measures, as those who self-report going without heating are indeed using their heating less than those who don't.

There was a smaller association between energy poverty and thermostat settings: people who reported having difficulty paying bills heated their homes to a slightly lower temperature than those who didn't report having difficulty. Therefore, there may be some potential for education around thermostat use to encourage people to heat to a lower temperature rather than go without heat at all. However, it is important to note this is only relevant to the half of the sample that own thermostats.

Heating empty homes and rooms is the most energy intensive inefficient behaviour we collect data on, and it was associated with being more likely spend 10% or more of household income on energy costs, but less likely to report going without heating and cutting back on essentials. This relationship highlights the strengths of the subjective energy poverty measures, that are better at capturing the experiences of people in energy poverty.

Interestingly, spending 10% or more of household income on energy costs has opposite relationship with heating behaviour than our subjective measures. People experiencing energy poverty by the expenditure measure are more likely to use heating, heated their homes for longer, and were also more likely to heat empty homes and rooms. This relationship suggests that behaviour is in some cases leading to experiencing energy poverty by this measure, and supports the literature that critiques the expenditure measure as a blunt indicator that includes those overconsuming energy.[11,13]

4.5. Conclusions

BETT has provided a unique opportunity to track multiple energy poverty measures across the year in Ireland, map how they interact and overlap, and reveal their relationships with home energy behaviours. Energy poverty is very prevalent in Ireland, regardless of the measure used, and most people experiencing energy poverty do so by multiple measures.

Our findings support critiques of the expenditure measure within the energy poverty literature. BETT also allowed us to examine the sociodemographic and dwelling characteristics of the energy poor according to different measures and has shone a light on the groups of people in Ireland who are more vulnerable to deprivation. These findings can inform which of these groups most need targeted support.

The significant minority spending 10% or more of their income on energy costs but not reporting experiencing energy poverty according to subjective measures, the proportion of people under-consuming heating to the point their energy costs are below the 10% threshold, and the relationship between high energy expenditure and inefficient heating behaviours support critiques that the expenditure measure includes people who can comfortably spend high proportions of their income on energy bills without experiencing deprivation and excludes people inadequately heating their homes to manage energy costs. Researchers and policy makers measuring energy poverty or interpreting findings should keep in mind the limitations of the expenditure measure.

Appendices

Appendix A – Sociodemographic and dwelling characteristics

Figure 7: Sociodemographic characteristics of the total sample, people having difficulty paying bills, going without heating, cutting back on essentials, and spending 10% or more of their income on energy costs.

Appendix B – Regression model results

For all models beta coefficients and associated standard errors (SE) are reported.
Statistical significance is denoted by "." where p<.1; a "*" where p < .05; ** where p < .01; and ***p < .001.

Characteristics and behaviours associated with energy poverty

Table 5: Logistic regression results showing the relationship between energy poverty using four different measures and time of year, sociodemographic variables, dwelling characteristics, and inefficient home energy behaviours. Model 1 does not control for income and Model 2 does.

		Difficulty paying bills		Going without heating		Cutting back on essentials		>10% income on energy	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Ref: Summer	Shoulder	0 (0.05)	-0.02 (0.05)	0.52 (0.06)***	0.55 (0.06)***	-0.01 (0.05)	0 (0.06)	0.46 (0.05)***	0.5 (0.06)***
	Winter	-0.02 (0.05)	-0.03 (0.05)	0.44 (0.06)***	0.49 (0.06)***	0.01 (0.05)	0.04 (0.06)	0.9 (0.06)***	1.01 (0.07)***
Sociodemographic characteristics									
Ref: Female	Male	-0.23 (0.04)***	-0.14 (0.04)***	-0.3 (0.05)***	-0.22 (0.05)***	-0.23 (0.05)***	-0.14 (0.05)**	-0.33 (0.05)***	-0.13 (0.05)*
Ref: 18-34	35 – 54	0.16 (0.05)**	0.15 (0.05)**	-0.16 (0.06)**	-0.17 (0.06)**	-0.04 (0.06)	-0.04 (0.06)	0.38 (0.06)***	0.4 (0.07)***
	55+	-0.08 (0.06)	-0.09 (0.07)	-0.59 (0.07)***	-0.61 (0.08)***	-0.66 (0.07)***	-0.68 (0.07)***	0.47 (0.07)***	0.42 (0.08)***
Ref: Rural	Urban	-0.24 (0.05)***	-0.21 (0.05)***	-0.08 (0.06)	-0.04 (0.06)	-0.17 (0.06)**	-0.13 (0.06)*	-0.14 (0.06)*	-0.07 (0.07)
Ref: ABC1	C2DEF	0.45 (0.04)***	0.34 (0.05)***	0.42 (0.05)***	0.29 (0.05)***	0.36 (0.05)***	0.23 (0.05)***	0.52 (0.05)***	0.21 (0.05)***
Ref: Below degree	Degree	-0.45 (0.05)***	-0.37 (0.05)***	-0.44 (0.06)***	-0.35 (0.06)***	-0.5 (0.05)***	-0.4 (0.05)***	-0.51 (0.05)***	-0.32 (0.06)***
Ref: Not employed	Employed	-0.21 (0.05)***	-0.33 (0.05)***	-0.16 (0.05)**	-0.3 (0.06)***	-0.25 (0.05)***	-0.4 (0.05)***	0.07 (0.05)	-0.25 (0.06)***
Ref: <€2k	€2k - €4k		-0.45 (0.05)***		-0.56 (0.06)***		-0.56 (0.06)***		-1.59 (0.06)***
	€4k+		-1.13 (0.07)***		-1.25 (0.08)***		-1.31 (0.08)***		-3.3 (0.09)***

Ref: Live alone	Couple	-0.18 (0.07)**	0.05 (0.07)	-0.43 (0.08)***	-0.16 (0.08).	-0.57 (0.08)***	-0.3 (0.08)***	-0.58 (0.08)***	0.17 (0.08)*
	Family	0.33 (0.07)***	0.53 (0.07)***	-0.17 (0.07)*	0.07 (0.08)	-0.13 (0.07).	0.11 (0.07)	-0.37 (0.07)***	0.48 (0.08)***
	Unrelated/mix	0.02 (0.11)	0.2 (0.11).	-0.34 (0.12)**	-0.15 (0.12)	-0.16 (0.11)	0.05 (0.11)	-0.35 (0.12)**	0.2 (0.13)
	Disability in hh	0.49 (0.05)***	0.41 (0.05)***	0.61 (0.05)***	0.51 (0.05)***	0.67 (0.05)***	0.57 (0.05)***	0.5 (0.05)***	0.34 (0.06)***
	Renter	0.63 (0.05)***	0.52 (0.05)***	0.71 (0.06)***	0.58 (0.06)***	0.72 (0.05)***	0.58 (0.05)***	0.66 (0.06)***	0.44 (0.07)***
Dwelling characteristics									
Ref: Detached	Apartment	-0.16 (0.09).	-0.14 (0.09)	-0.23 (0.1)*	-0.24 (0.11)*	-0.22 (0.1)*	-0.23 (0.1)*	-0.51 (0.1)***	-0.63 (0.11)***
	Semi-detached	0.07 (0.05)	0.09 (0.06)	0.06 (0.06)	0.08 (0.06)	0.12 (0.06)*	0.15 (0.06)*	-0.06 (0.06)	-0.07 (0.07)
	Terraced	0.07 (0.07)	0.06 (0.07)	0.19 (0.08)*	0.18 (0.08)*	0.19 (0.08)*	0.17 (0.08)*	-0.07 (0.08)	-0.16 (0.09).
Ref: Oil boiler	Electric	0.05 (0.09)	0.04 (0.09)	0.1 (0.1)	0.06 (0.1)	0.13 (0.09)	0.1 (0.1)	0.25 (0.1)*	0.31 (0.12)**
	Gas	0.03 (0.05)	0.05 (0.05)	-0.07 (0.06)	-0.07 (0.06)	0.08 (0.06)	0.1 (0.06)	0.15 (0.06)*	0.27 (0.07)***
	Heat pump/ district heating	-0.1 (0.11)	-0.09 (0.11)	-0.42 (0.13)**	-0.48 (0.14)***	0.12 (0.11)	0.11 (0.12)	-0.04 (0.13)	-0.12 (0.15)
	None	-0.24 (0.11)*	-0.27 (0.11)*	-0.17 (0.13)	-0.24 (0.13).	-0.23 (0.12).	-0.3 (0.13)*	-0.39 (0.14)**	-0.38 (0.16)*
	Solid fuel/biomass	0.01 (0.08)	-0.05 (0.08)	-0.12 (0.1)	-0.23 (0.1)*	0.12 (0.09)	0.02 (0.09)	0.1 (0.09)	-0.09 (0.1)
Ref: A/B/C1 BER	C2/C3/D	0.19 (0.07)**	0.15 (0.07)*	0.31 (0.08)***	0.28 (0.08)***	0.24 (0.07)***	0.21 (0.07)**	0.21 (0.07)**	0.15 (0.08).
	E/F/G/Exempt	0.26 (0.1)**	0.25 (0.1)*	0.54 (0.11)***	0.53 (0.11)***	0.45 (0.1)***	0.44 (0.11)***	0.12 (0.11)	0.16 (0.12)
Inefficient behaviours									
Heating unoccupied rooms/home			-0.05 (0.05)		-0.18 (0.06)**		-0.18 (0.06)**		0.24 (0.06)***
Inefficient hot water use			0.14 (0.06)*		0.2 (0.07)**		0.23 (0.07)***		0.17 (0.08)*
Cooking inefficiently			0.02 (0.05)		-0.02 (0.06)		-0.01 (0.05)		0.04 (0.06)

Inefficient washing machine use		0.16 (0.04)***		0.12 (0.05)*		0.18 (0.05)***		0 (0.06)
Tumble dryer		0.32 (0.05)***		0.24 (0.06)***		0.26 (0.06)***		0.33 (0.07)***
Inefficient dishwasher use		0.02 (0.05)		-0.13 (0.06)*		-0.09 (0.06)		0.03 (0.06)
	n=11,944	*n=11,944*	*n=11,944*	*n=11,944*	*n=11,944*	*n=11,944*	*n=9,616*	*n=9,616*

Table 6: Logistic regression results showing the relationship between experiencing energy poverty by all three subjective measures and time of year and sociodemographic characteristics. Model 1 does not control for income and Model 2 does.

		All three subjective measures of energy poverty							
		Model 1				Model 2			
		B (SE)	OR	CI (low)	CI (high)	B (SE)	OR	CI (low)	CI (high)
Ref: Summer	Shoulder	0.37 (0.07)***	1.45	1.27	1.65	0.38 (0.07)***	1.46	1.28	1.66
	Winter	0.28 (0.07)***	1.32	1.16	1.51	0.28 (0.07)***	1.32	1.15	1.51
Ref: Female	Male	-0.2 (0.06)***	0.82	0.73	0.91	-0.12 (0.06)*	0.88	0.79	0.99
Ref: 18-34	35 - 54	-0.11 (0.07)	0.90	0.79	1.03	-0.11 (0.07)	0.90	0.79	1.02
	55+	-0.64 (0.09)***	0.53	0.45	0.62	-0.71 (0.09)***	0.49	0.42	0.58
Ref: Rural	Urban	-0.06 (0.06)	0.94	0.84	1.05	-0.02 (0.06)	0.98	0.88	1.10
Ref: ABC1	C2DEF	0.55 (0.06)***	1.72	1.53	1.94	0.4 (0.06)***	1.49	1.32	1.68
Ref: Below degree	Degree	-0.47 (0.06)***	0.62	0.55	0.71	-0.38 (0.07)***	0.68	0.60	0.77
Ref: Not employed	Employed	-0.24 (0.06)***	0.79	0.70	0.89	-0.38 (0.06)***	0.68	0.60	0.78
Ref: <€2k	€2k - €4k					-0.54 (0.06)***	0.58	0.51	0.66
	€4k+					-1.38 (0.1)***	0.25	0.21	0.31
Ref: Live alone	Couple	-0.58 (0.1)***	0.56	0.46	0.67	-0.31 (0.1)**	0.74	0.61	0.89
	Family	-0.11 (0.08)	0.90	0.76	1.05	0.18 (0.08)*	1.20	1.02	1.42
	Unrelated/Mix	-0.39 (0.14)**	0.68	0.51	0.88	-0.16 (0.14)	0.85	0.64	1.11
	Disability in hh	0.63 (0.06)***	1.88	1.68	2.11	0.54 (0.06)***	1.71	1.53	1.92

	Renter	0.56 (0.06)***	1.75	1.56	1.97	0.43 (0.06)***	1.53	1.36	1.72
		n=12,000				*n=12,000*			

Energy poverty and heating behaviour

Table 7: Logistic regression results showing the relationship between energy poverty using four different measures and using (a) primary and (b) secondary heating in a given day if a participant was home on that day, while controlling for weather, time of year, and whether the reference day fell on a weekend.

	Difficulty paying bills		Going without heat		Cutting back on other essentials		>10% income on energy	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)
Heating season	1.57 (0.07)***	1.32 (0.09)***	1.61 (0.07)***	1.32 (0.09)***	1.58 (0.07)***	1.32 (0.09)***	1.55 (0.09)***	1.27 (0.11)***
Weekend	-0.1 (0.05)*	0.07 (0.05)	-0.1 (0.05)*	0.06 (0.05)	-0.1 (0.05)*	0.06 (0.05)	-0.12 (0.06).	0.05 (0.06)
Heating degrees	0.21 (0.01)***	0.13 (0.01)***	0.21 (0.01)***	0.13 (0.01)***	0.21 (0.01)***	0.13 (0.01)***	0.22 (0.01)***	0.13 (0.01)***
Very wet (>10 mm)	0.44 (0.12)***	0.34 (0.13)**	0.45 (0.12)***	0.34 (0.13)**	0.44 (0.12)***	0.34 (0.13)**	0.47 (0.14)***	0.22 (0.15)
Wet (1 - 10 mm)	0.2 (0.05)***	0.28 (0.05)***	0.21 (0.05)***	0.29 (0.05)***	0.2 (0.05)***	0.29 (0.05)***	0.32 (0.06)***	0.22 (0.06)***
Med sun (1-5 h)	-0.1 (0.06).	0.04 (0.06)	-0.09 (0.06).	0.04 (0.06)	-0.1 (0.06).	0.03 (0.06)	0 (0.07)	0.07 (0.07)
Sunny (5h+)	-0.25 (0.06)***	-0.19 (0.07)**	-0.24 (0.07)***	-0.19 (0.07)**	-0.25 (0.06)***	-0.19 (0.07)**	-0.19 (0.08)*	-0.19 (0.08)*
Windy (20 km/h+)	0.33 (0.05)***	0.2 (0.05)***	0.32 (0.05)***	0.2 (0.05)***	0.32 (0.05)***	0.2 (0.05)***	0.31 (0.06)***	0.24 (0.07)***
Energy poor	**-0.08 (0.05)**	**0.09 (0.05).**	**-0.37 (0.06)*** **	**0.01 (0.06)**	**-0.17 (0.05)*** **	**-0.03 (0.05)**	**0.14 (0.06)***	**0.43 (0.06)*** **
	n=11,335	*n=11,335*	*n=11,335*	*n=11,335*	*n=11,335*	*n=11,335*	*n=8,156*	*n=8,156*

Table 8: Logistic regression results showing the relationship between energy poverty using four different measures and using primary heating for (a) over 2 h (vs. under 2 h) and (b) over 4 h (vs. under 4 h) in a given day (assuming primary heating was used at all), while controlling for weather, time of year, and whether the reference day fell on a weekend.

	Difficulty paying bills		Going without heat		Cutting back on other essentials		>10% income on energy	
	> 2 h	> 4 h	> 2 h	> 4 h	> 2 h	> 4 h	> 2 h	> 4 h
	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)
Heating season	0.65 (0.14)***	0.23 (0.19)	0.66 (0.14)***	0.24 (0.19)	0.65 (0.14)***	0.24 (0.19)	0.71 (0.16)***	0.43 (0.24).
Weekend	-0.04 (0.06)	-0.09 (0.07)	-0.04 (0.06)	-0.09 (0.07)	-0.04 (0.06)	-0.09 (0.07)	0.04 (0.08)	-0.01 (0.08)
Heating degrees	0.14 (0.01)***	0.13 (0.01)***	0.14 (0.01)***	0.13 (0.01)***	0.14 (0.01)***	0.13 (0.01)***	0.14 (0.01)***	0.13 (0.01)***
Very wet (>10 mm)	0.04 (0.16)	0.08 (0.18)	0.04 (0.16)	0.08 (0.18)	0.05 (0.16)	0.08 (0.18)	0.09 (0.19)	0 (0.23)
Wet (1 - 10 mm)	0.08 (0.07)	-0.01 (0.07)	0.09 (0.07)	0 (0.07)	0.09 (0.07)	-0.01 (0.07)	0.05 (0.08)	-0.01 (0.09)
Med sun (1-5 h)	-0.11 (0.07)	-0.16 (0.07)*	-0.1 (0.07)	-0.15 (0.07)*	-0.11 (0.07)	-0.16 (0.07)*	-0.08 (0.08)	-0.12 (0.09)
Sunny (5h+)	-0.22 (0.09)*	-0.14 (0.09)	-0.22 (0.09)*	-0.14 (0.09)	-0.22 (0.09)*	-0.14 (0.09)	-0.18 (0.1).	0 (0.11)
Windy (20 km/h+)	0.16 (0.07)*	0.14 (0.08).	0.16 (0.07)*	0.13 (0.08).	0.16 (0.07)*	0.14 (0.08).	0.09 (0.08)	0.16 (0.09).
Energy poor	**-0.04 (0.06)**	**-0.18 (0.07)****	**-0.21 (0.07)****	**-0.34 (0.08)*****	**-0.16 (0.07)***	**-0.17 (0.08)***	**0.37 (0.07)*****	**0.38 (0.08)*****
	n=5,262	*n=5,262*	*n=5,262*	*n=5,262*	*n=5,262*	*n=5,262*	*n=3,820*	*n=3,820*

Table 9: Logistic regression results showing the relationship between energy poverty using four different measures and using thermostat settings of (a) 19°C or more (vs. 18°C or less) and (b) 21°C or more (vs. 20°C or less) in a given day (assuming primary heating was used on that day) , while controlling for weather, time of year, and whether the reference day fell on a weekend.

	Difficulty paying bills		Going without heat		Cutting back on other essentials		>10% income on energy	
	19°C +	21°C +	19°C +	21°C +	19°C +	21°C +	19°C +	21°C +
	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)
Heating season	0.5 (0.2)*	0.09 (0.22)	0.51 (0.2)**	0.09 (0.22)	0.48 (0.2)*	0.08 (0.22)	0.25 (0.23)	-0.19 (0.24)
Weekend	-0.08 (0.1)	-0.14 (0.1)	-0.08 (0.1)	-0.14 (0.1)	-0.09 (0.1)	-0.15 (0.1)	0.05 (0.11)	-0.13 (0.11)
Heating degrees	0 (0.01)	0.01 (0.01)	0 (0.01)	0.01 (0.01)	0 (0.01)	0.01 (0.01)	0.01 (0.02)	0.03 (0.02).
Very wet (>10 mm)	0.27 (0.25)	-0.53 (0.28).	0.27 (0.25)	-0.54 (0.28).	0.27 (0.25)	-0.54 (0.28).	0.19 (0.29)	-0.61 (0.33).
Wet (1 - 10 mm)	0.11 (0.1)	0.04 (0.1)	0.1 (0.1)	0.05 (0.1)	0.11 (0.1)	0.05 (0.1)	0.05 (0.12)	-0.02 (0.12)
Med sun (1-5 h)	0.05 (0.1)	-0.05 (0.1)	0.05 (0.1)	-0.05 (0.1)	0.04 (0.1)	-0.05 (0.1)	0.06 (0.12)	-0.01 (0.12)
Sunny (5h+)	-0.04 (0.13)	0.02 (0.13)	-0.04 (0.13)	0.01 (0.13)	-0.04 (0.13)	0.01 (0.13)	-0.01 (0.15)	0.05 (0.15)
Windy (20 km/h+)	-0.06 (0.1)	-0.04 (0.11)	-0.05 (0.1)	-0.04 (0.11)	-0.06 (0.1)	-0.05 (0.11)	-0.07 (0.12)	-0.03 (0.12)
Energy poor	**-0.12 (0.09)**	**0.14 (0.09)**	**-0.21 (0.11).**	**0.04 (0.11)**	**-0.39 (0.1)*** **	**-0.1 (0.1)**	**-0.02 (0.1)**	**-0.04 (0.1)**
	n=2,637	*n=2,637*	*n=2,637*	*n=2,637*	*n=2,637*	*n=2,637*	*n=1,965*	*n=1,965*

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