WORKING PAPER

Eurofound

Living conditions and quality of life

Surviving wint-her: A gendered analysis of energy poverty factors, drivers and outcomes

The cost-of-living crisis and energy poverty in the EU: Social impact and policy responses – Background paper

This paper supports the report entitled *The cost-of-living crisis and energy poverty in the EU: Social impact and policy responses - Background paper*.

Produced at the request of the Czech Presidency of the Council of the European Union for the High-level conference on 'Tackling energy poverty: EU approach & sharing best practices', Prague, 24 October 2022

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Eurofound reference number: WPEF23031

Related report: Eurofound (2022), *Fifth round of the Living, working and COVID-19 e-survey: Living in a new era of uncertainty*, Publications Office of the European Union, Luxembourg

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Introduction

Europeans are living in a time of deep economic uncertainty. The inflation in the European Union climaxed in November 2022, with an inflation rate of 11.5%, according to the Harmonized Index of Consumer Prices (HICP; Eurostat, 2023). The increase was driven mainly by skyrocketing energy prices, which increased by 34.9%, between November 2022 and November 2021 (Eurostat, 2023).

High inflation resulted from a combination of interconnected factors. In 2020, the COVID-19 pandemic halted worldwide global trade. In Europe, support policies were introduced to protect jobs and businesses from income losses. Help was financed by the European Central Bank (ECB) quantitative easing. By buying bonds to reduce loan rates, the measures maintained borrowing affordable but also led to the euro devaluation (EP, 2022). By April 2022, the ECB's maximum inflation target of 2%, implemented to ensure price stability in post-Covid Europe, was surpassed. In the aftermath of the Covid pandemic and despite a high inflationary context, Europe started to recover economically. However, the process was interrupted in February 2022 by the invasion of Ukraine by Russia.

'This is not only a war unleashed by Russia against Ukraine. This is a war on our energy, a war on our economy' (President von der Leyen, September 2022).

The invasion of Ukraine by Russia caused a humanitarian crisis marked by deaths, destruction, and a flux of Ukrainian refugees toward Europe. The European Union responded by adopting economic sanctions on Russia. In turn, Russia suppressed its oil and gas exports to Member States. Condemning Russia's attempt to weaponize its energy exports, the European Union decided to end its trade with the country. Yet, Russia was Europe's main supplier of natural gas, crude oil, and hard coal (Eurostat, 2022). The simultaneous inflation, war in Ukraine, and imminent winter made energy a top priority on the European Union's agenda.

To maintain energy affordable for households while ending Europe's dependency on Russian energy, numerous energy measures were adopted. In May 2022, the REpowerEU plan was implemented to accelerate the transition to clean and sustainable European-produced energy. It aimed at reducing Russian gas imports by 67%, by December 2022. This long-term plan was complemented by short-term measures to ensure households energy safety. The Gas Storage Regulation, adopted in June 2022, mandated Member States to maintain their gas facilities filled at a minimum of 80% for winter. The emergency resolution of September and October 2022 capped energy company prices and taxed their excess profits.

'We are safe for the winter' (President von der Leyen, December 2022).

The short-term targets set by European policies were met: by December 2022, gas imports from Russia had declined by 69% and 84% of European gas storage was filled, surpassing the 80% target

(EC, 2022). However, the number of European households in arrears with their utility bills increased from 13% in Spring 2021 to 16% in Spring 2022 (Eurofound, 2022). Additionally, in Spring 2022, 28% of Europeans expected to struggle to pay their utility bills in the next 3 months (Eurofound, 2022). Thus, the war in Ukraine, in the context of a high inflationary period and the upcoming winter, led to the surge of energy poverty in European households.

What is energy poverty?

> 'Energy poverty is a growing problem in the Community' (2009/72/EC).

Energy poverty is commonly understood as a situation in which households are unable to afford essential energy services and products (EC, 2020/1563). It entered the European Union agenda in 2009 with the Third Energy package. As energy poverty was identified as an obstacle to the well-functioning of the internal electricity market, Member States were mandated to take measures addressing this issue. Then, energy poverty was re-introduced in the European agenda, along the lines of sustainable development goals. In 2014, the Horizon Europe project was launched. Aiming at attributing grants to innovative research initiatives, part of the budget was attributed to energy efficiency projects. In 2015, the energy union package sought to ensure households' access to secure, sustainable, competitive, and affordable energy (COM/2015/080). In 2017, energy was identified as an essential service by the European Pillar of Social Rights, implying that energy access should be a right for everyone. In 2018, the European Energy Poverty Observatory was established. It is a platform of expertise to help stakeholders eradicate energy poverty (EPVO, 2023). In 2020, the European Commission adopted a recommendation on energy poverty, reaffirming the need for Member States to define energy poverty (EC, 2020/1563). Lastly, in April 2022, the European Commission established an energy poverty and vulnerable consumers coordination group (EC, 2022/2082). The group aims to ensure cooperation between European institutions and Member States to meet the European Green Deal targets. However, despite the multiplication of energy poverty policy development, a common European energy poverty definition and measurement have yet to be established.

Who are the vulnerable customers of energy?

> *'Each Member State shall define the concept of vulnerable customers' (2009/72/EC)*

Along with the introduction of energy poverty in the European agenda, the third energy package mandated Member States to identify and protect their energy vulnerable customers (2009/72/EC). Energy vulnerable customers are commonly understood as individuals at-risk of energy poverty. Progressively, in European legislation, common vulnerable customers' characteristics were identified as energy poverty risk factors. In 2015, the energy union package identified low income, general proverty conditions, inefficient homes, and 'housing tenure systems that fail to encourage energy efficiency' as energy poverty's main causes. In 2018, the Clean Energy for All Europeans package

established social housing as a risk factor due to its poor energy performance (EC, 2019). In 2022, the energy poverty and vulnerable consumers coordination group stated that the 'concept of vulnerable customers may include income levels, the share of energy expenditure of disposable income, the energy efficiency of homes, critical dependence on electrical equipment for health reasons, age or other criteria' (2022/589). Despite indications on who are the vulnerable energy customers, and similarly to energy poverty, a common European definition of energy vulnerable consumers has yet to be established.

Why are women at-greater risk of energy poverty?

'Women are at a greater risk of energy poverty than men' (EP, 2017)

The lack of common European energy poverty and vulnerable customers' definitions leads to different metrics, and thus, various estimates of the energy poor population. Measures on the share of Europeans unable to keep their home warm range from 8% (Eurostat, 2020) to 13% (EmpowerMed, 2020). The share of European households struggling to pay their energy bills is evaluated between 7% (Eurostat, 2018) and 11.7% (EmpowerMed, 2020). The scarcity of energy poverty measures is exacerbated when looking at gender-disaggregated estimates. In France, 38% of the 5.6 million households that declared being cold in 2013 are women-headed households with or without children (ANAH, 2013[1]). In Spain, 9% of low-income men-headed households were energy poor in 2016 compared to 11% of low-income women-headed households (Asociacion de Ciencias Ambientales, 2016[1]). Yet, at the European level, the share of energy poor by gender has not been evaluated, despite an agreement that women are at greater risk of energy poverty (EP, 2017).

In December 2016, the European Parliament regulated on the necessity to include gender in all energy poverty policies (2016/2885/EP). To provide stakeholders with the appropriate tools to analyse energy poverty through a gender lens, the European Parliament established an energy poverty framework (figure 1). By identifying the gender gaps operating in the drivers (▭) and outcomes (▭) of energy poverty, the framework both breaks with the gender-blindness of energy policies and their sole focus on economic vulnerability.

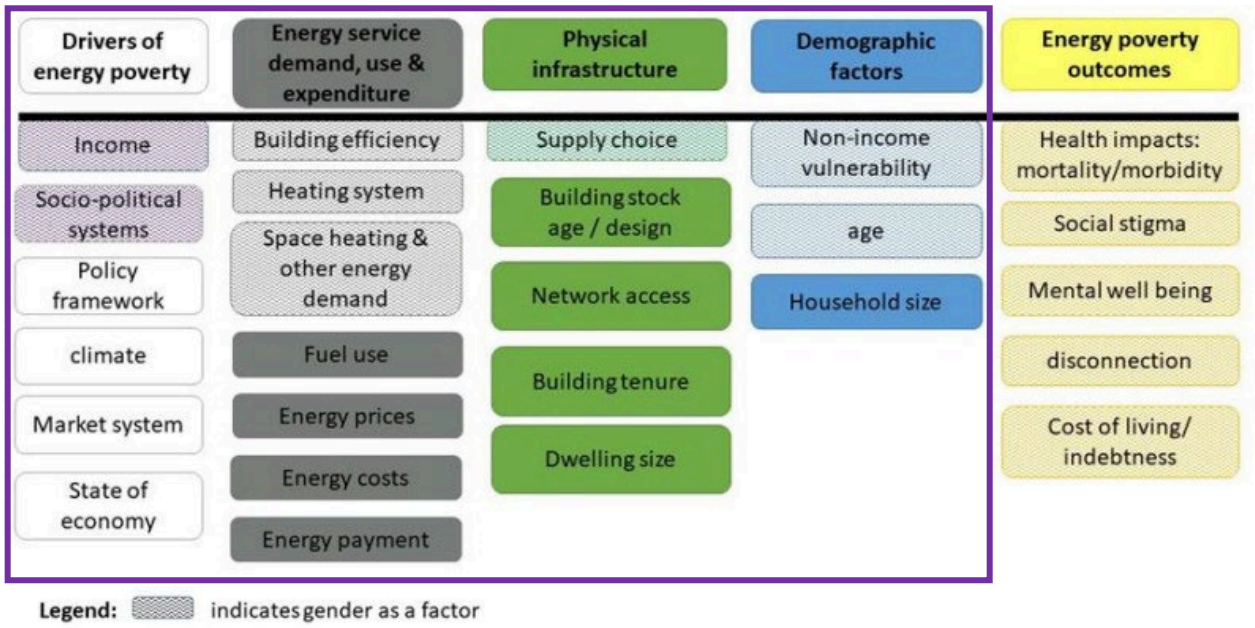
The research

This research explores the association between energy poverty and gender, using the European Parliament framework (figure 1) as an analytical lens. To support and complete the framework, an engendered literature review is conducted. It suggests that gender is an energy poverty factor, meaning that its specific interaction with energy poverty drivers and outcomes produces gender-bias consequences. Household types and gendered household types (the interaction between household types and gender) are identified as additional energy poverty factors. The European Parliament framework is then operationalized, using data from Eurofound's Living, Working, and Covid-19 e-

[1] cited in the European Parliament study, 2017

survey (LWC). The statistical analysis revealed the multi-dimensionality of energy poverty, with drivers and outcomes ranging beyond economic vulnerability. The research concludes that gendered household type is the main factor of energy poverty, with single mothers being at-greater risk of energy poverty while women living alone being more vulnerable to its adverse consequences.

Figure 1: The European Parliament energy poverty framework



Source: European Parliament's Policy Department C: Citizens' Rights and Constitutional Affairs, adapted from Trinomics, 2017

The data

The Eurofound Living, working, and Covid-19 e-survey (LWC) was launched in Spring 2020 to capture the impact of Covid on Europeans. It was then followed by 4 waves. The fifth one was fielded in Spring 2022, during a context marked by the war in Ukraine, raising inflation, and a sharp increase in the cost of living. To capture the emergence of a new era of uncertainty, additional questions on energy, housing, and payment difficulties were included. As the gender of the respondents was asked systematically, the survey provides a unique opportunity to use disaggregated pan-European data. It is to note that as the sampling methodology is non-probabilistic, the data is weighted to reflect the demographic profile of the population in terms of age, gender, region, and education for each Member State and for the European Union (Eurofound, 2020).

The structure

The European Parliament's energy poverty framework is the backbone of this research, and each chapter explores elements of it. In chapter 1.1, energy poverty is defined and operationalized, using the LWC dataset. Then, the chapter proceeds with the identification and operationalization of energy poverty factors: gender (▨), household types, and gender household types. In Chapter 2, an engendered literature review is conducted, to evidence the interaction between energy poverty factors, drivers (▭) and outcomes (▭). Then, based on the LWC data availability, variables are selected as indicators for each energy poverty driver and outcome. Chapter 3 statistically

investigates the association between energy poverty factors and drivers (). Lastly, chapter 4 quantitatively explores the link between energy poverty factors and outcomes (). The research concludes on the policy pointers that can be inferred from the results.

Chapter 1 – Energy poverty: definitions and factors

Despite the Third Energy Package's impetus to nationally define energy poverty, only 7 Member States have established definitions: Slovakia, France, Ireland, Cyprus, Spain, Belgium, Romania. The review of each definition allowed for the selection of an energy poverty indicator reflecting the best their commonalities, among the available LWC variables. Then, drawing on the European Parliament's engendered framework, a definition of energy poverty factor is elaborated. Scoping the literature on the subject and the data availability led to selecting gender, household types, and gendered household types, as energy poverty factors.

1.2 - Energy Poverty

1.1.1 - Defining Energy Poverty

When developing the energy poverty framework (figure 1), the European Parliament first sought to specify energy poverty. In its study, the institution reported that only 4 Member States have officially defined the concept: Slovakia, France, Ireland, and Cyprus (EP, 2017). It led to the conclusion that 'an agreed definition of energy poverty has proved elusive and contested' (EP, 2017). In 2020, Empower Med updated national policies evaluation, identifying 3 additional Member States with official poverty definitions: Belgium, Spain, and Romania (EmpowerMed, 2020). Empower Med is a project that was funded by the European Union in 2019 to develop engendered energy poverty knowledge. It aims at empowering women to act against energy poverty and formulate adequate policy recommendations. The policy review has been completed using the EuroFound Policy Watch, a database gathering national measures introduced to cushion adverse social and economic effects.

Member States, in defining energy poverty, first identified what constitutes energy. Some definitions designate energy through its sources. In Slovakia, energy represents 'electricity, gas, heating, and hot water' (Thomson, 2016[2]). In Ireland 'energy services includ[e] heating, lighting, etc.' (DCENR, 2014[2]) while only 'heating' is considered in Romania (Legea nr. 196/2016[3]). In other Member States, energy remains unspecified: 'energy supply' in France (ONPE, 2014[2]), 'supply of electricity' in Cyprus (Pye et al., 2015[2]), or 'energy services' in Belgium (KBF, 2015[3]). Therefore, national definitions of energy are context-dependent and rather evasive, despite access to clean and sustainable energy for all being a priority in the context of the European Green Deal (EC, 2023).

Secondly, across all Member States, energy poverty is defined generically. It refers to covering 'minimum energy needs' in Romania (Legea nr. 196/2016[3]), 'satisfying elementary needs' in France (ONPE, 2014[2]), to respond to 'reasonable needs' in Cyprus (Pye et al., 2015[2]), or to 'meet basic

[2] cited in the European Parliament study, 2017

[3] cited in EmpowerMed, 2020

energy supply' in Spain (Miteco, 2019[4]). Therefore, the threshold to determine energy poverty is relative to each household's perceptions of its energy needs.

Thirdly, in every definition, potential causes of energy poverty are identified. However, if income is mentioned as an energy poverty driver in each definition, additional causes differ. Households are considered energy poor if they spend a 'substantial share of the[ir] average monthly income' on energy in Slovakia (Thomson, 2016[5]), if energy expenditures represent a 'significant portion of disposable income', in Cyprus (Pye et al., 2015[5]), or if they spend 'too high a portion of income on energy', in Belgium (KBF, 2015[4]). In Ireland, energy poverty is due to the inability to meet energy services, 'at affordable cost' (DCENR, 2014[5]) while it is attributed to 'an insufficient level of income in Spain' (Miteco, 2019[4]). Additionally, France and Spain included 'housing conditions' (ONPE, 2014[5]) as an additional energy poverty driver. Cyprus went further by stating that energy poverty 'refers to the situation of consumers who may be in a difficult position because of their low income […] in conjunction with their professional status, marital status, and specific health conditions' (Pye et al., 2015[5]). Therefore, if for every Member State energy poverty is an economic issue, it is a multi-dimensional one only for Cyprus.

Lastly, 3 Member States: Ireland, France, and Belgium have established official energy poverty metrics. All refers to a ratio between income and energy expenditures. In France and Ireland, a household faces energy poverty when the ratio between its energy expenses and income is above 10%. In Belgium, a household is in energy poverty if it is in the lower-income decile and spends over twice the median energy expenditure.

1.1.2 – Operationalisation and data

From the overview of Member States' energy poverty definitions, 2 main common characteristics emerge. Firstly, the relativity of energy poverty, as energy needs (consumption levels and sources) vary across households and Member States. Secondly, the centrality of economic means, with income being identified as the main energy poverty driver. Among the LWC-19 dataset, the variable 'household in arrears with utility bills' reflects both the relativity and economic centrality of energy poverty definitions. Thus, the variable has been selected as an indicator of energy poverty. The summary of this measurement is provided in Table 1.

It is to note that selected arrears with utility bills as a proxy implies framing energy poverty from an expenditure perspective. This measurement misses households' energy needs. It may be that households restrict their energy use to avoid being in arrears or over-consume and thus end up unable to pay their bills as scheduled. Additionally, this measurement does not consider energy sources, due to the lack of data availability on access to clean and sustainable energy. Lastly, arrears with utility bills may capture poverty more broadly. This is a common concern when studying energy poverty, yet various researchers evidenced that if poverty and energy poverty intersect, they do not

[4] cited in EmpowerMed, 2020

[5] cited in the European Parliament study, 2017

completely overlap (King Baudouin Foundation, 2015; Scottish Fuel Poverty Forum, 2015[6]). The correlation between household income decile, used as a proxy for poverty, and arrears with utility bills, used as a proxy for energy poverty, revealed only a moderate association between both variables (annex 1).

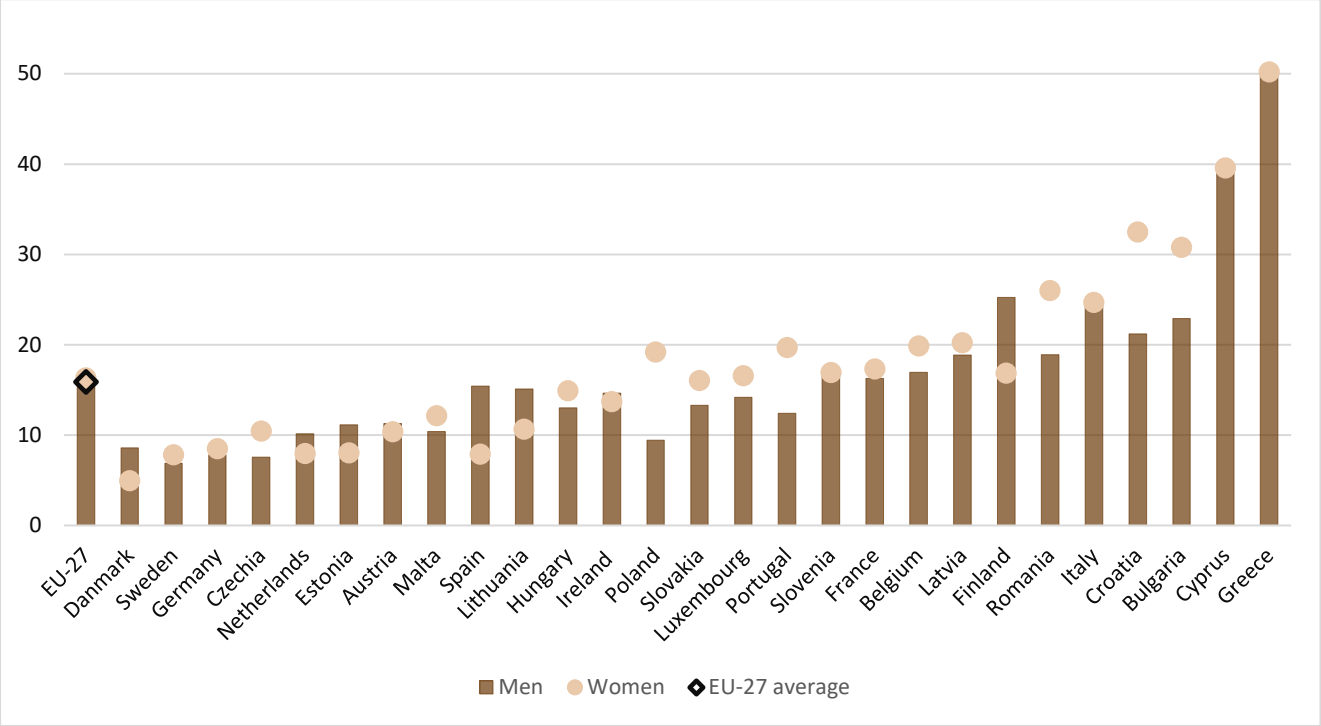
Table 1: Operationalized energy poverty

Energy poverty	E-survey question	Values
Arrears in utility bills	*Has your household been in arrears at any time during the past 3 months, that is, unable to pay as scheduled utility bills?*	Binary variable, with 0: no arrears, and 1: in arrears

Figure 2 reports the share of energy poor population, by gender, across Member States. In Spring 2022, 15.9% of Europeans were energy poor, with rates ranging from 6.7% in Denmark to 50.3% in Greece. Besides Greece, other Southern Member States – Greece (50.3%), Cyprus (39.5%), Croatia (26.9%), Italy (24.7%), Portugal (16.2%) – have a share of their population in energy poverty higher than the European average. Looking across gender, at the European level, 15.4% of men are in energy poverty compared to 16.3% of women. Across Member States, 17 have a higher share of women than men in energy poverty. The widest gender gap is found in Croatia, with 21.2% of men in energy poverty compared to 32.5% of women, which is an 11.3 percentage points difference. Oppositely, Spain is the Member State with the widest difference between a higher share of men (15.4%) than women (7.9%) in energy poverty. Therefore, variations in energy poverty rates are recorded, across both Member States and gender.

[6] cited in Jones, 2016

Figure 2: Population in energy poverty, by gender and Member States, EU-27 (in %)



Has your household been in arrears at any time during the past 3 months, that is, unable to pay as scheduled utility bills? In energy poverty as % of the respondents responding 'Yes'.
Source: Eurofound's Living, Working and COVID-19 e-survey, Wave5: March-May 2022
Note: Member States are ranked by their average energy poverty rate, from the lowest to the highest

1.2 - Energy poverty factors

From figure 2, a gender gap in the share of energy poor population is identifiable. Mainstream arguments explain that more women are in energy poverty because they earn less than men, and by extension are less able to pay their utility bills (EPVO, 2020). In Spring 2020, the gender gap in the share of the energy poor population was at 0.5 percentage point, compared to 0.9 percentage point in Spring 2022. Over the same period, the gender pay gap remained unchanged, at a 13-percentage point difference (EC, 2022). These opposite trends suggest that, if necessary, economic disparities do not appear sufficient to explain the increasing gender gaps in energy poverty. Drawing on the European Parliament framework (figure 1), these gaps are explained by identifying gender as an energy poverty factor, that is a socio-economic characteristic interacting with energy poverty drivers and outcomes in a specific way. Additional energy poverty drivers are identified by reviewing the current research on energy poverty.

1.1.2 – Identifying energy poverty factors

Gender

The European Parliament framework (figure 1) identifies gender as an energy poverty factor, interacting with both its drivers and outcomes. The rationale behind the framework is the existence of gender gaps in 3 main spheres: economic, biological, and socio-cultural perspectives. It leads to the interaction between gender and energy poverty drivers, which results in women being at higher risk of being in energy poverty. Additionally, gender gaps also operate in energy poverty outcomes, which results in women being more likely to be negatively affected by energy poverty consequences, due to the interaction between gender and energy poverty outcomes. A detailed overview of the interaction between gender and energy poverty drivers and outcomes is available in Chapter 2. Therefore, from the European Parliament study (EP, 2017), gender emerges as an energy poverty factor due to its systematic and specific interactions with energy poverty drivers and outcomes, producing gender-bias consequences.

Existing research on gender and energy poverty corroborates the conceptualization of gender as an energy poverty factor. The Empower Med project identifies gender inequality as a risk factor increasing women's vulnerability to energy poverty. Understanding energy poverty is framed as a socio-economic and socio-cultural problem, allows to grasp how current inequalities are replicated. (EmpowerMed, 2018).

The Energy Poverty Observatory listed gender among socio-economic characteristics rendering individuals more vulnerable to energy poverty, along with old age, low-income, low educational achievement, and disability. However, in the following analysis, due to the lack of evidence on the interaction with energy poverty drivers and outcomes, these socio-economic characteristics are considered as drivers, rather than factors of energy poverty. However, ethnicity, household types, and the interaction between household types and gender are identified in the literature as potential energy poverty factors.

Ethnicity

Research on ethnicity as an energy poverty factor is mainly limited to the United States, despite evidence that ethnic minorities, and in particular African Americans, are at greater risk of energy poverty (Energy Justice Dashboard, 2023; Jessel and al. 2019). Estimates on the difference in energy burden between black and white households range from 2.1 (Drehobl and Ross, 2016) to 8-percentage point (Downer et al., 2021[7]). In the United Kingdom, 16.4% of ethnic minority households are in energy poverty compared to 10.4% of white households (Department for business, energy, and industrial strategy, 2017[8]).

[7] cited in Dogan and al., 2022

[8] cited in the European Parliament study, 2017

The intersection between energy poverty drivers and ethnicity results in a higher share of ethnic minorities among the energy poor population.

Firstly, looking at country-level drivers (figure 1), in terms of income, African Americans earn on average 40.5% less than white households and Latinos 31% less (Census Bureau, 2011). Then, racial racism is a structural inequality, implying that discrimination, if not considered is systematically replicated in socio-political systems (Rokhaya Diallo, 2020).

Secondly, considering energy service, demand, use & expenditures, ethnic minorities live in more energy inefficient accommodations. African Americans' annual utility costs per square foot are 22% higher than white households (Drehobl and Ross, 2016). Regarding appliance efficiency, ethnic minorities have limited access to low-carbon technologies (Goldstein and al., 2022). For example, black-dominant neighbourhoods have 61% less solar rooftops installed and Hispanic 45% less, than the average, while white-dominated neighbourhoods have 37% more, controlling for home ownership and income (Castellanos and al. 2019). Regarding energy use, on a per capita basis, Caucasian neighbourhoods consume more energy than African Americans, themselves consuming more than Latinx neighbourhoods, controlling for energy demands, electricity's carbon intensity, and building age (Goldstein and al., 2022). It creates an emissions paradox, since African Americans have both low energy efficiency accommodations and appliances, and low per capita emissions, while the opposite is true for white households (Goldstein and al., 2022).

Thirdly, exploring physical infrastructure, and more particularly supply choice, racial segregation is pre-eminent in the United States. It led to African Americans being disproportionally found in older, energy inefficient homes, with outdated appliances (Lewis and al., 2020[9]). Regarding network access, racial segregation is prevalent in cities, spilling over into higher difficulties to access energy and good-quality housing (Jessel and al., 2019). In terms of dwelling size, Latinos live in smaller dwellings than African American, themselves living in smaller accommodations than whites (Drehobl and Ross, 2016).

Lastly, looking at demographic drivers, racial and ethnic minorities gaps persist in educational achievement (Stanford, 2023) and employment outcomes (Williams and Wilson, 2019). As both act as protective factors (Legendre, 2015; Bell and al., 2015[10]), minorities are more vulnerable to energy poverty.

The higher share of minorities suffering from energy poverty is attributed to the intersection between energy poverty outcomes and ethnicity. Yet, the literature on the interconnection between energy poverty, ethnicity, and energy poverty outcomes, other than physical health remains limited. Due to energy poverty, black residents have a higher mortality rate during heatwaves (O'Neils and al., 2005[11]) and racial-minority neighbourhoods have a higher exposure rate to environmental hazards (Jessel and al., 2019). Regarding energy disconnection rates, Black and Hispanic households

[9] cited in Goldstein and al., 2022

[10] cited in the European Parliament study, 2017

[11] cited in Jessel and al., 2019

are more likely to be disconnected from electricity services, controlling for education, employment, household types, and building tenure (Memmot, and al., 2023[12]). Fear of disconnection has been associated with stigma and mental health disorders (Hernandez, 2016).

Due to the lack of data availability on ethnicity, this energy poverty factor has been excluded from the analysis.

Household types

Energy poverty occurs at the household, rather than, at the individual level. Households are the energy users, with specific energy needs and spending abilities (EP, 2017). Especially, as most energy poverty drivers operate at the household level, household types appear as specifically and systematically interacting with energy poverty drivers (figure 1). In terms of outcomes, most consequences of energy poverty also affect the whole household. For example, indoor air pollution, inadequate temperatures, indebtedness, and restricting energy use occur at the household level (see details in Chapter 2). However, the literature on the subject remains limited, with indications that being a single parent may imply an additional vulnerability to energy poverty (EP, 2017). To fill the gap, household type is considered as an energy poverty factor.

Gendered household types

Engendering energy poverty requires recognising that households are heterogeneous entities (EP, 2017). Especially, in a heteronormative society, exploring the interaction between gender and household types appears central to single out the effect of gender on energy poverty. The literature suggests that both gender and household type interact systematically and specifically with energy poverty drivers and outcomes, producing biased consequences for women and single parents. Thus, it is hypothesized that the interaction between gender and household types will similarly interact in a systematic and specific way with energy poverty drivers and outcomes, producing gendered household types-bias consequences. Therefore, gendered household type is considered as an energy poverty factor.

1.2.2 – Operationalisation and data

Energy poverty factors interact with energy poverty drivers and outcomes, in specific ways, ranging beyond existing inequalities. Combining the European Parliament framework (figure 1) and the current research suggests the following energy poverty factors: gender, ethnicity, household types, and gendered household types.

To investigate quantitatively their interaction with energy poverty, variables have been selected as indicators of energy poverty factors. Firstly, gender is measured, using men and women as a proxy. For an issue of representativeness respondents identifying their gender as other (147 respondents) have been excluded. Secondly, due to the lack of data availability, ethnicity has been excluded from

[12] cited in Goldstein and al., 2022

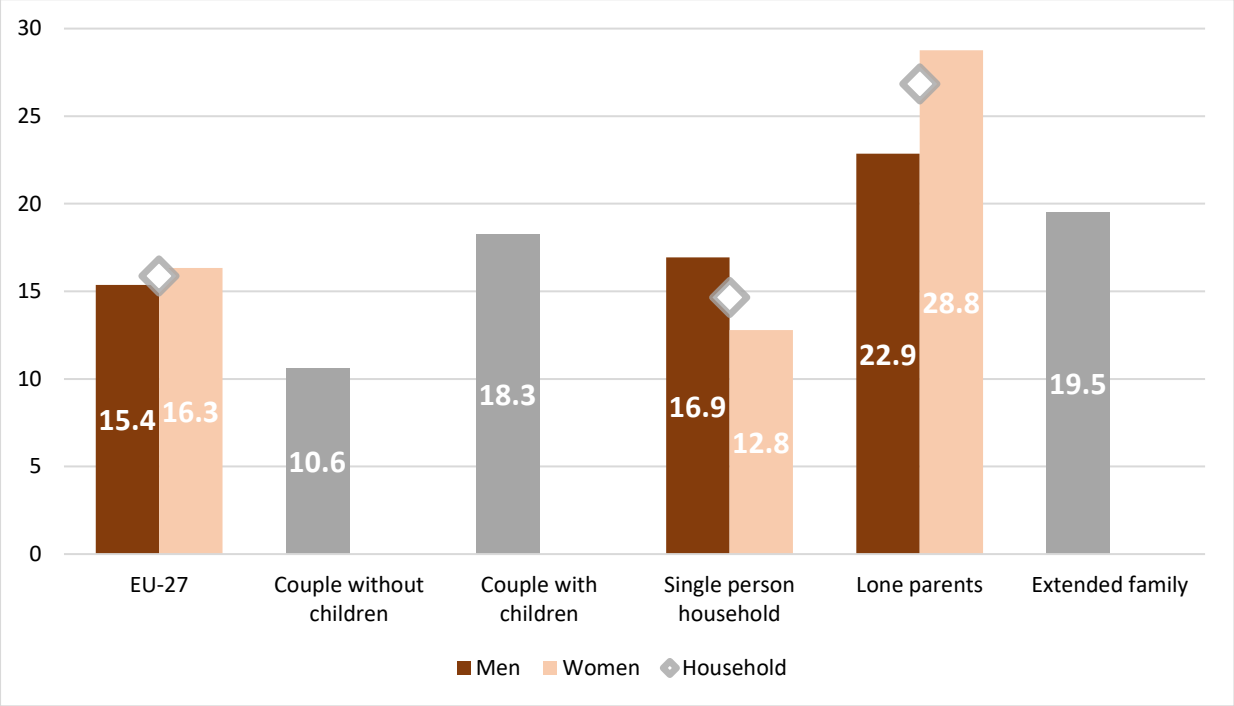
the analysis. Thirdly, household types have been divided into 5 categories: couples without children, couples with children, individuals living alone, lone parents, and extended families. Lastly, in Europe, 97.9% of couples are estimated to be heterosexual (ESS, round 10, 2020). Thus, the gendered household types variables consider the gender of the respondents solely for single parents and individuals living alone. Table 2 provides details on the energy poverty factor indicators.

Table 2: Operationalized energy poverty factors

Variables	Values
Gender	Categorical variable, with: 1: men, 2: women
Household types	Categorical variable, with: 1: couple without children – spouse/partner living in the household 2: couple with children – spouse/partner and children living in the household 3: living alone 4: lone parents – children living in the household 5: extended families – parents/grandparent living in the household
Gendered household type	Categorical variable, with: 1: couple without children, 2: couple with children, 3: men living alone, 4: women living alone, 5: single fathers, 6: single mothers, 7: extended family

Figure 3 reports the share of the population in energy poverty, by gendered household types, in Spring 2022. Overall, in Europe, 15.9% of individuals are energy poor. If a higher share of women (16.3%) than men (15.4%) are energy poor at the European level, this is not systematically the case for every gendered household configuration. Among single-person households, a higher percentage of men (16.9%) than women (12.8%) are energy poor. The gendered household type with the highest energy poverty rate (26.8%) is lone parents, with 22.9% of single fathers and 28.8% of single mothers being energy poor. Oppositely, couple without children (10.6%) is the gendered household type with the lowest share of individuals being energy poor.

Figure 3: Share of population in energy poverty by gendered household types, 2022, EU-27 (in %)



Has your household been in arrears at any time during the past 3 months, that is, unable to pay as scheduled utility bills? In energy poverty as % of the respondents responding 'Yes'.
Source: Eurofound's Living, Working and COVID-19 e-survey (March-May 2022)

Summary: energy poverty and factors

Energy poverty depends on households' economic ability to fulfil their energy needs. To reflect the relativity and financial centrality of national energy poverty definitions, energy poverty is measured by whether households are in arrears with their utility bills (table 1). Energy poverty factors interact with energy poverty drivers and outcomes, in specific ways, ranging beyond existing inequalities. Combining the European Parliament's framework (figure 1), the current energy poverty research, and LWC data availability, the following analysis focuses on gender, household types, and gendered household types as energy poverty drivers (table 2).

Chapter 2 – Energy Poverty: drivers and outcomes

The European Parliament's framework identifies a set of energy poverty drivers and outcomes and frames gender as a factor interacting with both (figure 1). The engendered energy poverty literature review suggested that ethnicity, household types, and gendered household types may also be relevant energy poverty factors. For each component of the European Parliament's framework, the current research is reviewed to justify its association with energy poverty and, where relevant, with its factors. Then, to measure the association between energy poverty factors, drivers, and outcomes, variables from the LWC dataset are selected, where available, as indicators of energy poverty drivers and outcomes.

2.1 – Energy poverty drivers

An element is considered an energy poverty driver if it affects energy affordability, that is individuals' ability to economically fulfil their energy needs. It signifies that the presence of the driver renders paying for utility bills more difficult. The European Parliament framework has grouped energy poverty drivers into 4 categories (figure 1): drivers of energy poverty, energy service demand & use & expenditure, physical infrastructure, and demographic factors. As gender is indicated as a factor interacting with energy poverty drivers, the following section provides an engendered literature review of energy poverty drivers.

2.1.1 – Engendering the literature on energy poverty drivers

Drivers of energy poverty

Drivers of energy poverty refer to country-level characteristics, including: income, socio-political systems, policy framework, climate, market systems, and state of the economy (figure 1). Especially, the political and economic systems determine the energy market systems characteristics (extent of liberalization, level of competition….) and the policy frameworks protecting vulnerable consumers. The state of the economy shaped households' available income to spend on the energy market. While income is identified in the European Parliament's framework as a country-level driver (figure 1), it will be considered, in the following analysis, as an individual energy poverty driver. Lastly, climate influences energy demands, with Mediterranean Member States having higher cooling demands while Nordic ones have higher heating demands (EmpowerMed, 2023). Due to the lack of data availability, the scarcity of energy poverty policies, and the difficulty of quantitatively operationalizing market and socio-political systems, country-level drivers are omitted from the analysis. Nevertheless, country differences will be controlled for in the statistical model elaborated in this paper, through the inclusion of country-fixed effects.

Energy service demand, use, and expenditures

Housing thermal quality

The thermal quality of housing is determined by both building and heating system efficiency. Firstly, building efficiency refers to housing's ability to retain energy indoors. Energy inefficient dwellings require a higher energy consumption to achieve the same level of comfort as energy efficient homes (EPVO, 2020). The higher energy consumption level recorded in women-headed households (Elsnakat and Gomez, 2015[13]) may thus be explained by low-income women-headed households being disproportionally found in energy inefficient accommodations (Eurofound, 2020). Secondly, heating system efficiency is measured by the ratio between the energy used and the energy available by the user to fulfil his needs (heating, cooling ect). In Europe, a significant share of buildings has outdated boilers, with an energy efficiency of 60% while modern have an efficiency of over 95% (Anagnostopulous and DeGroote, 2016). However, households tend not to replace them until they break down. Especially, due to societal gender norms, women are less likely than men to be experienced with home repairs. In the UK, in 2012, 75% of home repairs were only or usually undertaken by men, in heterosexual couples (Scott and Clery, 2013). As the main reason not to replace a heater is dominated by the lack of information (Anagnostopulous and DeGroote, 2016), women, declaring that technical appliances language is too complex (Scott and Clery, 2013), appear more likely to keep using outdated boilers.

Energy needs

Energy needs refer to households' energy demands needed and the purpose of their use. When referring to energy poverty, the main purpose of energy use is living comfortably. In Europe, 104 million citizens are unable to keep their homes adequately cool while 57 million are unable to keep them comfortably warm (EmpowerMed, 2023). Due to physiological reasons, women are more sensitive to ambient temperature and thus have higher energy demands (Empower Med, 2020). Yet, Räty and Carlsson-Kanyamaa (2010[13]) evidenced higher energy consumption levels for single men than women, in Germany, Greece, Norway, and Sweden. Thus, it may be that women have higher energy demands, and yet are less able to meet them.

Energy expenditures

Energy expenditures have 3 components: energy prices, costs, and payments. Firstly, energy prices are an absolute measure of energy expenditure. It refers to the price per energy unit. Energy prices depend on market fluctuations, geo-political, and economic contexts. From 2010 to 2021, for European medium size households, the electricity prices per kilowatt increased by 27.7%, while the gas prices per gigajoule, increased by 13.5% (Eurostat, 2021). Secondly, energy cost is a relative component of energy expenditure. It accounts for energy supplies available given the price paid. Low-income are often limited in their ability to reduce energy costs, due to providers' limited offers and economic imperative. A common option for them is prepaid tariff meters. Yet, they imply paying for energy at a higher rate (Sunikka-Blank, 2017[13]). Thirdly, energy payment is the ratio between

[13] cited in the European Parliament study, 2017

disposable income and energy bills. From 2005 to 2011, the Electricity Price Index increased five times more than income per capita (Jones, 2016). It resulted in energy becoming the second expenditure, after food, for low-income households (Velody, 2003[14]). Thus, energy has become more expensive in absolute and relative terms, especially for low-income households.

Physical Infrastructure

Building tenure

Building tenure refers to the status of the person living in a property. Improvements in rented properties are associated with efficiency-related split incentives, as in the short-term, renovation costs will be covered by the owner, but benefit the occupier (Castellazzi and al., 2017). Oppositely, homeowners and landlords paying for energy bills directly benefit from the money invested in improvements. These economic incentives result in owners' energy bills being 2% lower than renters (Melvin, 2018) and in worst energy efficiency in rented, and especially social rented, accommodations (Eurofound, 2023).

Building characteristics

Building characteristics encompass building age, design, size, and location. Over half of the European building stock has been constructed quickly and at a low cost in the post-World War II period (Anagnostopoulos and De Groote, 2016). Thermal requirements were quasi-non-existent (EPEE, 2009[16]). Today, the result is an old and outdated building stock, with poor energy performances, that deteriorated over time. More recent dwellings are subjected to improved standards, including safer energy sources following the European commitment to Zero Energy Building. In terms of building design, in Europe, 58% of the population is living in single-family units (detached, semi-detached, terraced houses) and 42% of the population in multi-family units (apartments, flats, bedsits) (Anagnostopoulos and De Groote, 2016). As multi-family accommodations involve homogenized building techniques, renovations can be standardized. It implies cheaper and quicker energy improvements. Oppositely, since single-family houses are not identically constructed, they require expensive tailored renovations. Additionally, dwelling size also influences energy consumption, as the bigger the accommodation, the highest the energy needed (EP, 2017). Lastly, network access, or the building location, drives energy poverty as rural respondents are more likely to be owners of large houses, with leaks, dampness, and rots. It results in rural respondents struggling more than urban respondents to keep their houses warm (Eurofound, forthcoming 2023).

Supply choice

Supply depends on the housing market, including accommodation availability and affordability. Supply choice is a gendered energy poverty driver as prejudices persist in the housing allocation process (Ringelheim and Bernard, 2013). Men applicants are often privileged over women, and especially over single mothers and unmarried women, as they are seen as more capable of handling properties (Ringelheim and Bernard, 2013). Thus, women are less able to access high-quality

[14] cited in Jones, 2016

housing. As an example, in the United Kingdom, 24% of women with children live in poor-quality housing, compared to 13% of men with children (Equality and Human Rights Commission, 2011[15]).

Socio-Demographic Characteristics

Non-income vulnerability

When considering non-income vulnerability, education, employment, and disability are identified in the literature as energy poverty's main drivers. Firstly, in France, a low level of education increases exposure to fuel poverty. The odds of being energy poor are 72.6% higher for individuals with no diploma compared to ones with secondary education, controlling for household characteristics, energy sources, and household types (Legendre, 2015). Secondly, inactive and unemployed individuals spent more time in their homes and thus have higher energy demands (Bell et al., 2015[16]). Yet, gendered household types interplay with employment status. For instance, there is an 18-percentage point difference in the employment rate of men and women with children. The employment gap is of 12-percentage points when comparing men and women without children (Eurostat, 2021). Thirdly, individuals suffering from a long-term sickness or disability are more likely to be energy poor (Jones, 2016). In 2022, in Europe, 58% of disabled people were women (Eurostat, 2023).

Income vulnerability

The Maastricht Treaty established a single European energy market. It implied both the liberalization and privatization of energy services. Thus, income determines the spending power of households, both on their energy bills (EPOV, 2020) and on energy-efficient housing and appliances (Empower Med, 2020). As low-income households have less spending power in the energy market, they are disproportionately found among the energy poor population. It is to note that poverty and energy poverty are correlated, but do not completely overlap. For example, in Belgium, over 50% of households in energy poverty are not at-risk of income poverty (King Baudouin Foundation, 2015[17]) while in Scotland, it is the case for 58% of households (Scottish Fuel Poverty Forum, 2015[19]).

Age

Age influences energy needs, with children and older people being particularly vulnerable to heat and cold stress (Chard and Walker, 2016[18]). Women have a life expectancy at birth of 83.5 years compared to 78.3 years for men (Eurostat, 2019). Yet, in 2019, women had a pension, on average, 29% lower than men (Eurostat, 2019). Thus, women are likely to be over-represented as heads of older households, to have higher energy demands, but to be less able to pay for their utility bills than men. Therefore, older women are more likely to be in energy poverty.

[15] cited in Ringelheim and Bernard, 2013

[16] cited in the European Parliament study, 2017

[17] cited in Jones, 2016

Household Size

Household size is the number of people living in one dwelling. If the energy used increases as the household size increases, the rise is not proportional. In fact, one-person households have the highest average energy footprint per capita in Europe while households of more than four members have the lowest (Ivanova and Büchs, 2020).

2.1.2 - Operationalisation and data

The engendered literature review provides evidence of the interaction between gender and the energy poverty drivers as identified by the European Parliament (figure 1). It suggests that the interaction goes beyond the scope of existing imbalances and produces gender-specific outcomes. It results in women, and especially single mothers, being at greater risk of energy poverty.

To investigate the association between energy poverty factors, drivers, and outcomes, variables from the LWC dataset have been selected as indicators for energy poverty drivers. However, due to the lack of data availability, the following drivers are missing from the analysis: fuel use, space heating, and energy prices expenditures (prices, costs, and payments). As it can lead to an omitted variable bias, the following research is a gendered analysis of energy poverty, based on the partial operationalization of the European Parliament framework (figure 4). For the analysis, variables have been recoded. Details on the original variables and the data manipulation are available in the annex (annex 2).

Table 3: Operationalized energy poverty drivers

	Drivers	Values
Country drivers	Country	Categorical variable, with EU-27 countries from 1: Austria to 27: Sweden
Energy service demand & use	Building Efficiency	Binary variable, with 0: energy efficient building and 1: energy inefficient building
	Energy Demands	Binary variable, with 0: less or equal importance and 1: more importance
Physical Infrastructure	Supply Choice	Binary variable, with 0: satisfied with accommodation, and 1: not satisfied
	Building Stock	Categorical variable, with 1: multi-family housing and 2: single-family housing
	Network Access	Categorical variable, with 1: city/city suburbs 2: towns, 3: countryside
	Building Tenure	Categorical variable, with 0: owner and 1: renter
	Dwelling Size	Binary variable, with 0: no dwelling size issues and 1: dwelling size issues
Socio-demographic drivers	Employment Status	Categorical variable, with 1: employed, 2: unemployed, 3: inactive (long-term illness or disability, homemaker, retired), 4: student
	Education Level	Categorical variable, with 1: lower than secondary, 2: secondary, 3: tertiary education

	Disability	Categorical variable, with 0: no and 1: yes
	Income	Continuous variable, with scale from 1: 25% top of the income distribution to 4: 25% bottom of the distribution
	Age	Continuous variable, with range from 18 to 94
	Household size	Continuous variable, with range from 1 to 10+

2.2 – Energy poverty outcomes

Labelling a phenomenon as an energy poverty outcome implies that individuals experience a specific variation in the outcome (worsening or bettering) when their energy poverty status changes. The European Parliament framework identifies 5 energy poverty outcomes (figure 1), grouped into 3 categories: health (both mental and physical), societal exclusion (disconnection and social stigma), and indebtedness. Gender is indicated as a factor interacting with all 5 outcomes (figure 1).

2.2.1 – Engendered literature review

Health

Physical health

Research identifies 3 main physical health outcomes resulting from energy poverty: excess deaths, indoor air pollution, and cold indoor temperature. Excess seasonal deaths are the number of additional deaths per season compared to the average death rate. Excess winter seasonal death is strongly linked to the quality of housing and ability to heat it (Marmot Review, 2011[18]). Particularly, women, and especially older women, are more likely to be affected by excess winter mortality (Boardman, 2010[19]; EP, 2017). Secondly, due to providers' limited offers, outdated energy systems, and cheaper prices, energy poor households are sometimes forced to use unhealthy energy sources, such as solid fuel (coal, wood…) (Anagnostopoulos and De Groote, 2016). As women are the main responsible for household energy intensive activities, such as cooking and cleaning, energy poor women are associated with a higher exposure risk ratio to indoor air pollution (World Bank, 2012[21]). It results in women being more likely to contract respiratory and eye diseases (EP, 2017). Thirdly, living in energy poverty inhibit household capacity to achieve comfortable energy levels. While cold indoor temperature increases the risk of cardiovascular illnesses, hot indoor temperatures are linked to heat stroke, stress, and excess deaths (EPOV, 2020).

[18] cited in Jones, 2016

[19] cited in the European Parliament study, 2017

Mental health

Research has evidenced that energy poverty affects different domains of mental health. Firstly, it inhibits the feeling of security and homeliness due to energy poor households' inability to achieve comfortable energy levels (EPOV, 2020). Secondly, household inaptitude to heat their homes adequately is associated with lower mental well-being and a higher risk of depression (Thomson et al., 2016[20]). Thirdly, higher anxiety, stress, and depression levels are recorded among the energy poor population due to the necessity to balance their energy bills with their energy needs (EP, 2017). Especially, in Ireland, being in energy poverty has been found to statistically increase the likelihood of depression for parents, with a higher rate for mothers than fathers (Mohan, 2021).

Societal Exclusion

Findings suggest that energy poverty increases the likelihood to experience social stigma and disconnection, resulting in greater societal exclusion. To cope with energy poverty, households may ration their electricity consumption. For example, they may limit their number of showers or washing machine uses. It may lead to energy poor children suffering from social stigma or bullying, as they are sometimes referred to as smelly or stinky (EPOV, 2020). Living in energy poverty may also hinder social interactions. In Scotland, the energy poor declared to be reluctant to invite guests into their homes due to their inappropriate indoor temperature (Thompson, 2017[21]). Lastly, living in energy poverty has been associated with anti-social behaviours, including drug use and truancy (EPOV, 2020), as well as, with attention and motivation deficiency (Jones, 2016).

Thus, in the literature, a clear connection between energy poverty and societal exclusion is evidenced. Also, women are at higher risk of poverty and societal exclusion (22.6%) than men (20.7%) (Eurostat, 2021). However, little research has been conducted on the interconnection between energy poverty, societal exclusion, and gender. Current literature on gendered societal exclusion focuses on domestic work burden. Prior to the pandemic, women spent a weekly average of 15.8 hours on unpaid work compared to 6.8 hours for men, prior to the pandemic (EIGE, 2022). As a result, most of their free time is spent inside their home rather than in social activities (EmpowerMed, 2021). Especially, as gender division intensifies under material stress (Bomdi and Christie, 2000[22]), energy poverty may be a catalyst of unequal domestic work division. Energy poor women may be further isolated inside their homes, and consequently further excluded from society.

Indebtness

Indebtedness is often an immediate impact of energy poverty, as energy poor individuals face unaffordable utility bills. Indeed, 68% of European households stated utility bills as a major driver of

[20] cited in Tod and Thompson, 2016

[21] cited in the European Parliament study, 2017

[22] cited in Robinson, 2019

their indebtedness (Jones, 2016). Due to limited financial manoeuvre, energy poor are often forced to contract debt from loan sharks, with higher interest rates, which push them into a debt spiral (Jones, 2016). Research has also evidenced the interconnection between gender and debt. In heterosexual couples, men are mainly responsible for financial decisions, including debt acquisitions. Yet, it is women who manage debt and day-to-day budgeting (Callegari, Liedgren, Kullberg, 2020). It implies that women face greater financial and emotional stress, with limited action possibilities. The gendered division in debt acquisition and management differs among household types. Women's responsibility for debt management is exacerbated in households with children, as they are viewed as the main carer for their families. It is minimized in middle-income couples without children. Also, single mothers are more likely to contract debt due to their weaker connections to the labour market (Callegari, Liedgren, Kullberg, 2020). While the interconnection between energy poverty and debt, and between debt and gender has been explained, the association between energy poverty, debt, and gender has yet to be evidenced.

2.2.2 – Operationalisation and data

The review of the literature highlighted that being in energy poverty may worsen physical and mental health, increase feelings of social stigma and disconnection, and foster Indebtness. Additionally, it suggests that if women are more likely to suffer from its adverse outcomes, the magnitude of the impact depends on their household types. Yet, the direct link between energy poverty, gender, and energy poverty outcomes is missing in the current research. To fill this gap, energy poverty outcomes have been operationalized using the LWC dataset. Details on the original variables from the e-survey are included in the annex (annex 2).

Table 4: Operationalized energy poverty outcomes

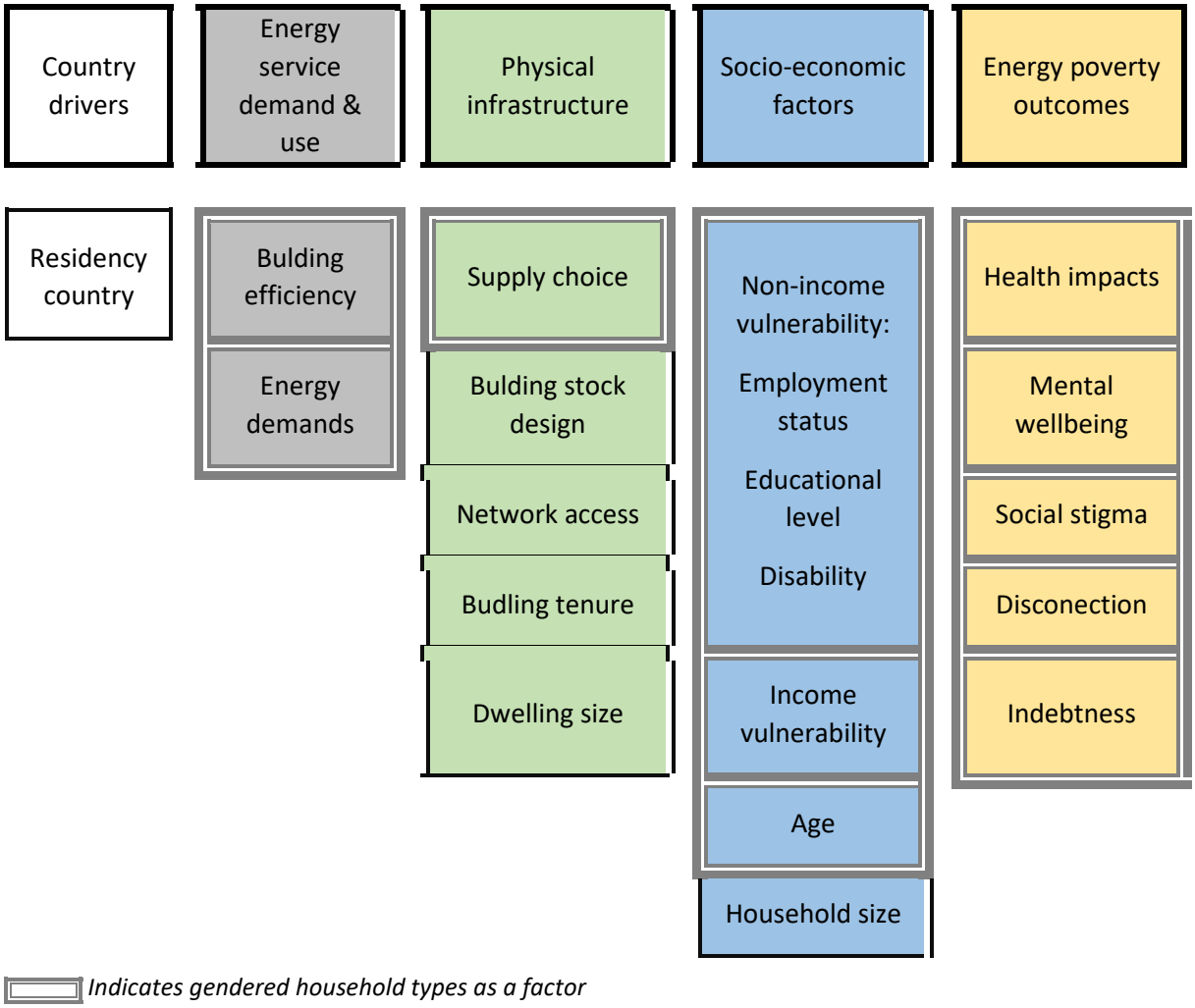
	Outcomes	Values
Health	Health impacts	Continuous variable, with scale from 1: very good to 5: very bad health
	Mental well being	Continuous variable, with scale from 1: very good to 5: very poor mental health
Societal Exclusion	Social stigma	Continuous variable, with scale from 1: strongly disagree to 5: strongly agree
	Disconnection	Continuous variable, with scale from 1: at no time to 6: all the time
Cost of living	Indebtness	Continuous variable, with scale from 1: 12+ months to 5: no savings

Summary: energy poverty drivers and outcomes

The European Parliament framework postulates that gender is a factor interacting with energy poverty multi-dimensional drivers and outcomes. The literature on the subject supports this conceptualisation but suggests additional energy poverty factors: household types and gendered household types. The partial operationalisation of the energy poverty framework, based on the LWC

data availability, the European Parliament framework, and the engendered literature review is summarized in Figure 4:

Figure 4: Operationalized European Parliament's energy poverty framework, using the LWC dataset



Chapter 3 – Energy poverty: drivers and factors

The European Parliament framework identifies 4 main categories of energy poverty drivers: country drivers, energy service demand & use & expenditure, physical infrastructure, and socio-demographic drivers (figure 1). Based on its partial operationalization (figure 4), this chapter first aims at quantifying the association between energy poverty and its drivers (figure 5). Additionally, the European Parliament framed gender as a factor interacting with some energy poverty drivers. The engendered literature review of energy poverty drivers (chapter 1.2) suggested that household types and gendered household types may also be relevant energy poverty factors interacting with the drivers. Thus, this chapter then aims at determining the association between energy poverty and its factors (figure 6 and figure 7).

3.1 – Energy poverty drivers

3.1.1 – Methodology

Given energy poverty binary outcome, a logit regression has been conducted, to determine the drivers (Zi) significantly influencing the odds to be in energy poverty (Yi). The model has been tested for the absence of multicollinearity (mean VIF: 2.17, see annex 3)

Odds ratios measure the difference between the probability to be energy poor given the presence of a driver and the probability to be in energy poverty given the absence of this driver. Odds ratios below 1 are associated with lower odds in the outcome (not in energy poverty), while odds ratios above 1 are associated with higher odds (in energy poverty).

Model 1: Logit regression - energy poverty on energy poverty drivers

$$\text{Odds } Yi = \beta 0i + \beta i\, Zi + ui + \varepsilon i$$

with: ui: country fixed effects

By detailing energy poverty drivers (table 3), the following model is obtained:

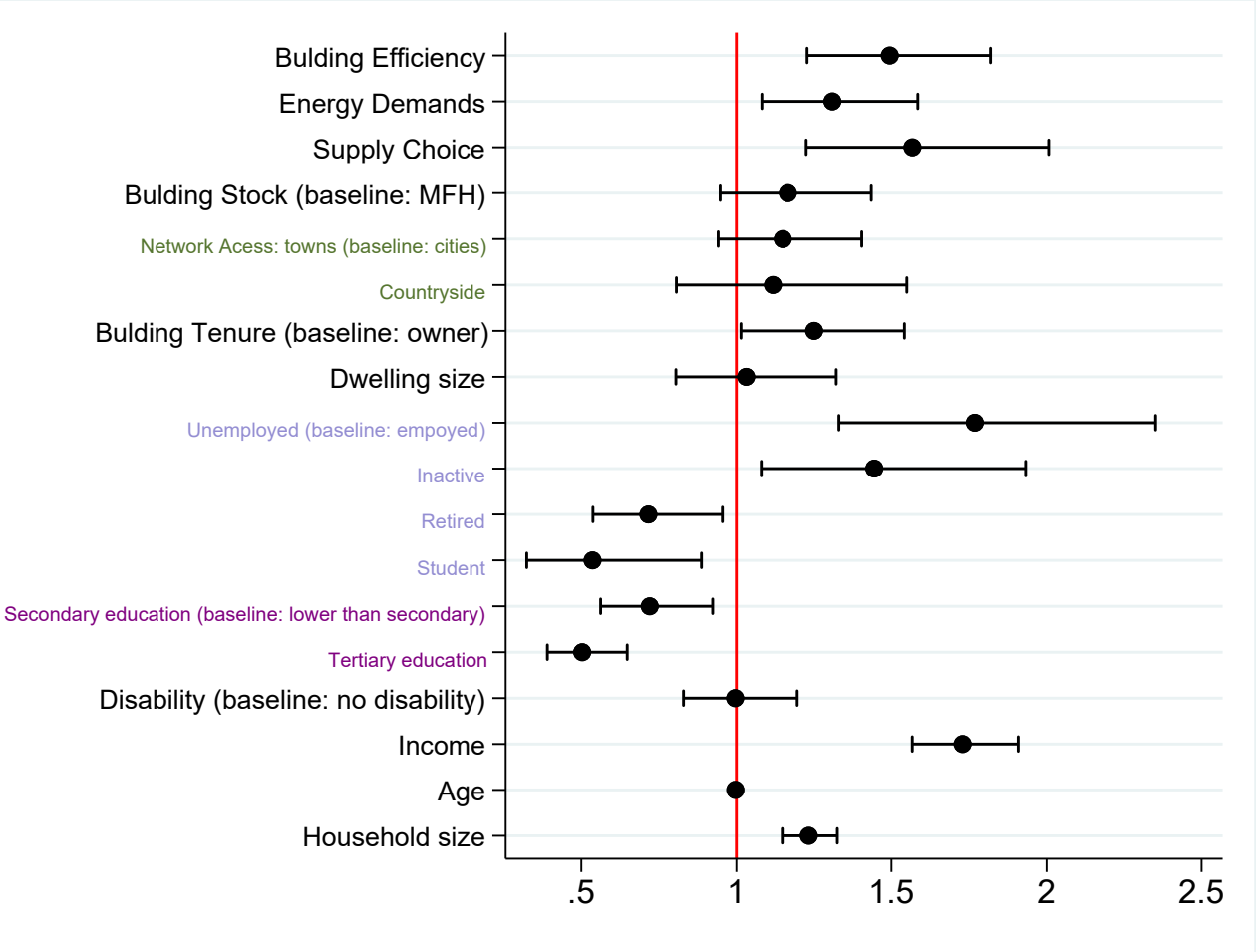
$$\text{Odds } Yi = \beta 0 + \beta 1 \text{ building efficiency} + \beta 2 \text{ energy demands} + \beta 3 \text{ supply choice} + \beta 4 \text{ building stock} + \beta 5 \text{ network access} + \beta 6 \text{ building tenure} + \beta 7 \text{ dwelling size} + \beta 8 \text{ employment status} + \beta 9 \text{ education} + \beta 10 \text{ disability} + \beta 11 \text{ income} + \beta 11 \text{ age} + \beta 12 \text{ household size} + ui + \varepsilon i$$

with: β: energy service demand & use; β: physical infrastructure; β: socio-demographic characteristics

3.1.2 – Results and interpretation

Figure 5 is a visualisation of the odds that respondents are in energy poverty as a function of the energy poverty drivers operationalized (table 3). Country-fixed effects are not reported, but the full regression table is available in the annex (annex 4).

Figure 5: Odds ratio - energy poverty drivers



Source: Author's own calculation, based on Eurofound's Living, Working and COVID-19 e-survey (Spring 2022).
Note: visualization from Model 1. Logit regressions results of energy poverty on energy poverty drivers (energy demand & use, physical infrastructure, socio-demographic characteristics), with country-fixed effects.
The baseline for each categorical variable is indicated in parenthesis. Variables have been coded from the best outcome (lowest value) to the worst (highest value).

Energy demands and use

Among the operationalized energy demands & use & expenditures drivers (table 3), both building efficiency and energy demands drivers significantly influence the odds of being energy poor. In fact, individuals living in energy inefficient accommodations are 59.9% more likely to be in energy poverty than individuals in energy efficient accommodations (p= odds /(odds-1)*100). Households whose energy demands have increased since covid are 56.7% more likely to be energy poor than households whose energy demands have remained the same or declined.

Physical infrastructure

Among physical infrastructure drivers, only supply choice and building tenure are significant predictors of being in energy poverty. Households dissatisfied with their accommodation are 61.1% more likely to be energy poor than satisfied households. In terms of building tenure, renters are 55.6% more likely than homeowners to be energy poor.

Socio-demographic factors

To account for non-income vulnerability, the following indicators have been selected: employment status, education level, and disability (table 3). Except for disability, all are significant predictors of the odds of being energy poor. Unemployed (+50.8%) and inactive (+59.1%) respondents are more likely to be in energy poverty than employed respondents, while retired (-28.4%) individuals and students (-46.4%) are less likely. In terms of education, the highest the education level, the lower the odds of being in energy poverty. In fact, the odds of being in energy poverty for people with respectively secondary and tertiary education are 27.9% and 49.7% lower than for induvial with below secondary education.

Income is associated with the widest variation in the odds of being in energy poverty, with a 63.4% increase in the odds to be energy poor for a decrease in income brackets. Yet, it is to note that energy poverty has been framed from an expenditure perspective, which de facto implies a stronger effect of expenditure-related variables. Therefore, energy poverty is an additional vulnerability, going beyond income.

Age does not significantly influence the odds of being in energy poverty.

Lastly, household size is a significant predictor of energy poverty, with a 55.2% increase in the odds of being in energy poverty for an extra-household member.

3.2 – Energy poverty drivers, gender, and household types

3.2.1 – Methodology

Models 2 and 3 explore the association between energy poverty and its factors: gender, household types, and gendered household types (table 2). Particularly, Model 2 first estimates whether gender (Xi) and household types (Ci) significantly influence the odds of being in energy poverty (Yi). Model 3 then estimates whether the interaction between gender and household types (Xi#Ci) is a significant predictor of the odds to be energy poor (Yi). Both model control for energy poverty drivers (Zi). Country-fixed effects have been included (uij).

Model 2: Logit regression - energy poverty on gender and household types

$$\text{Odds } Yi = \beta 0i + \beta 1i\, Xi + \beta 2i\, Ci + \beta 3i\, Zi + uij + \varepsilon i$$

Model 3: Logit regression - energy poverty on gendered household types

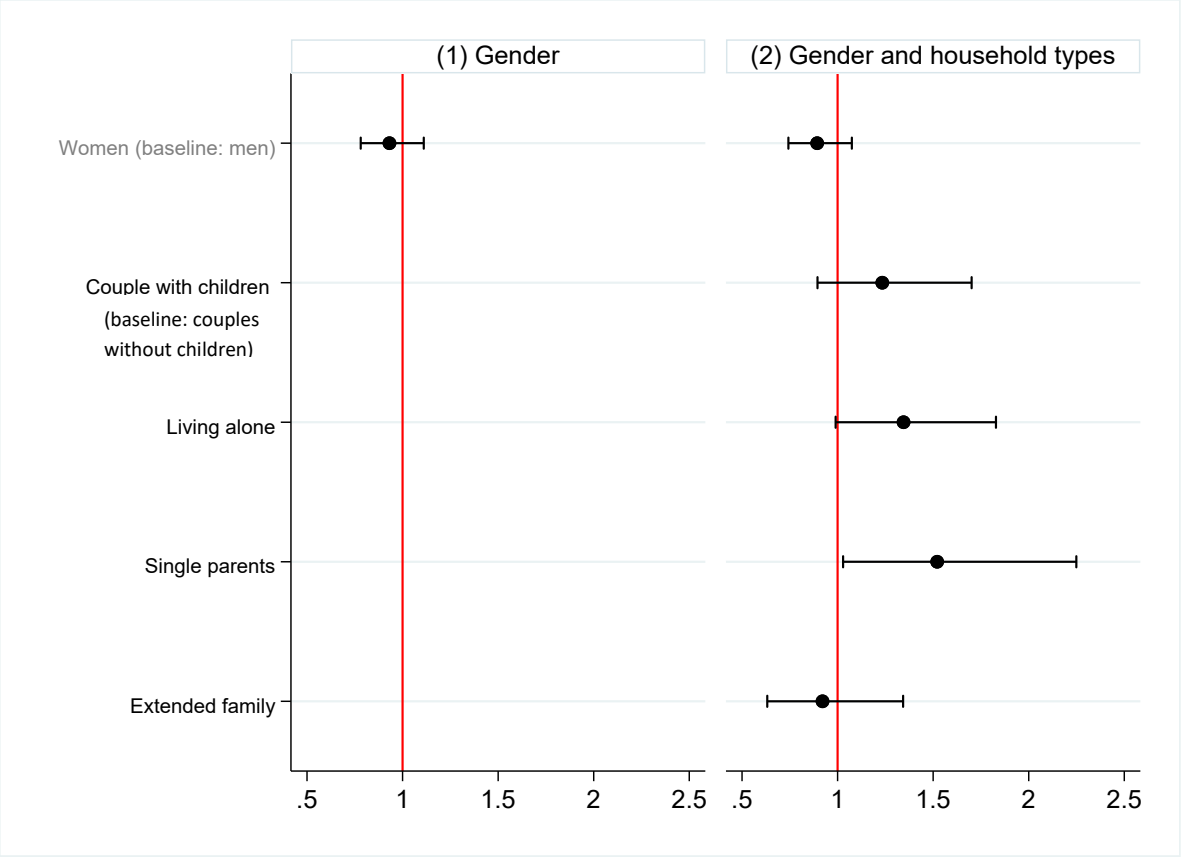
$$\text{Odds } Yi = \beta 0i + \beta 1i\ Xi\ \#\ Ci + \beta 2i\ Zi + uij + \varepsilon i$$

3.2.2 – Results and interpretation

Gender and household types

Figure 6 is a visualization of the results from Model 3. Figure 6(1) predicts the odds that respondents are in energy poverty, as a function of their gender. Figure 6(2) reports changes in the odds that respondents are in energy poverty as a function of their gender and household configurations. Controls and country-fixed effects are not reported for visualization clarity, but the full regression outputs are available in the annex (see annex 5).

Figure 6: Odds ratio - energy poverty on gender and household types



Source: Author's own calculation, based on Eurofound's Living, Working and COVID-19 e-survey (Spring 2022)
Note: visualization from Model 2. Logit regression results from energy poverty on energy poverty factors (gender and household types), controlling for energy poverty drivers (energy demand & use, physical infrastructure, individual characteristics, as reported in figure 5), with country-fixed effects.

Gender

Surprisingly, gender does not significantly influence the odds of being in energy poverty.

As the engendered literature review in Chapter 1.1 suggested that gender is interacting with energy poverty drivers in a specific way, it may be that the gender effect of energy poverty is captured in the drivers included in Model 2 (table 3). However, when running the null model of energy poverty on gender, without control, gender remains non-significant (annex 6).

As energy poverty is operationalized at the household level (table 1) it may be that household's composition is hiding the gender effect. Especially, given society's heteronormativity, most couples tend to be a man and a woman. Therefore, exploring the gender effect of energy poverty implies looking at household types not involving the presence of both genders: men and women living alone, as well as, single fathers and single mothers.

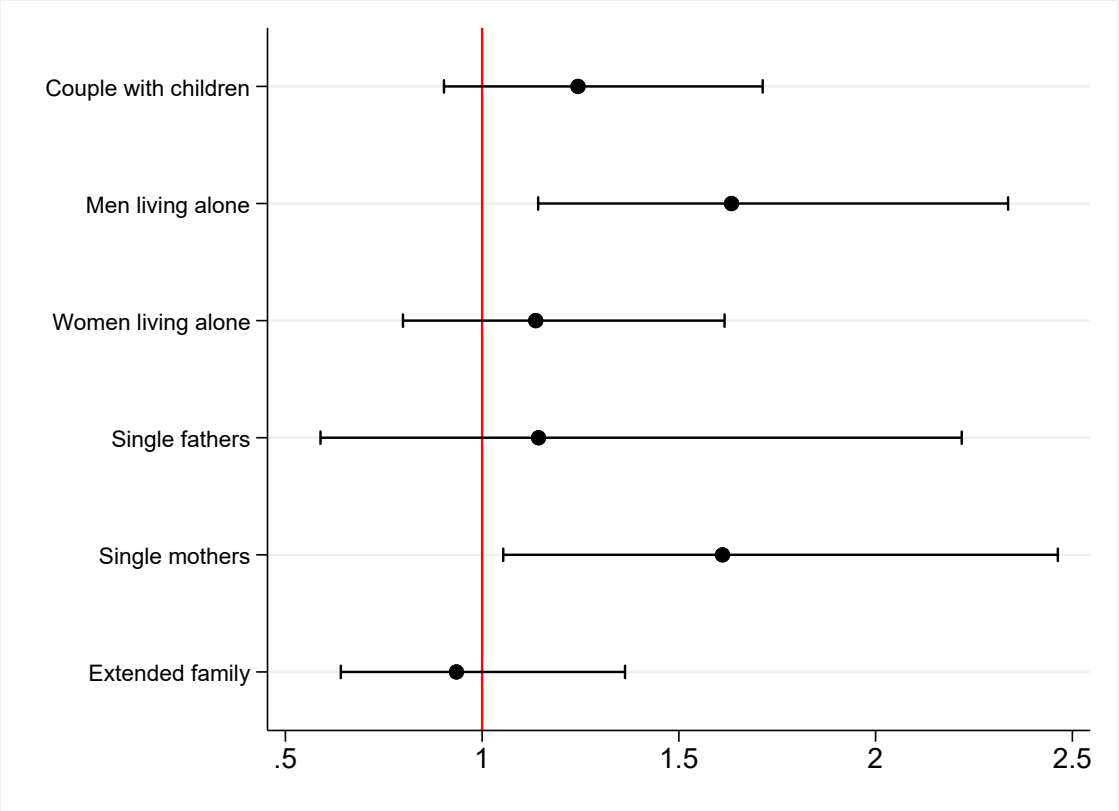
Household types

By comparison to couples without children, single parents are the only household type implying a significant increase (+60.3%) in the odds of being in energy poverty (figure 6(2)).

Gendered household types

Figure 7 is the visualization of the results from Model 3, predicting the odds that respondents are in energy poverty, as a function of their gendered household types. Comparing the confidence intervals for men and women in similar household configurations allows to grasp whether gender or household types is influencing the odds of being energy poor. If both coefficients are significant and the confidence intervals overlap, then household types are driving the odds. If both coefficients are significant and the confidence intervals do not overlap, then both household types and gender are driving the odds. If only one coefficient is significant then the interaction between gender and household types is driving the odds. The full model outputs, including energy poverty drivers and country fixed effects, is available in the annex (annex 7).

Figure 7: Odds ratio - energy poverty on gendered household types



Source: Author's own calculation, based on Eurofound's Living, Working and COVID-19 e-survey (Spring 2022)
Note: visualization from Model 3. Logit regression results of energy poverty on the interaction between gender and household types, controlling for energy poverty drivers (energy demand & use, physical infrastructure, individual characteristics), with country-fixed effects.
The baseline category for gendered household configurations is couples without children.

Compared to couples with children, men living alone (+62%) and single mothers (+61.7%) are the only gendered household types associated with a significant increase in the odds of being energy poor. It is to note that in terms of the magnitude of the changes associated with energy poverty, men living alone, and single mothers are associated with the largest variation after unemployment (+66.2%) and income (+63.4%). Therefore, gendered household types are associated with a variation in the odds of being in energy poverty, with being a man living alone or a single mother implying an extra vulnerability to energy poverty.

Summary: energy poverty drivers and factors

Energy poverty is a multi-dimensional issue, driven by a set of interconnected factors. Especially, building efficiency, energy demands, supply choice, building tenure, non-income vulnerability (employment and education), income vulnerability, and household size, are drivers associated with a significant variation in the odds of being in energy poverty.

Surprisingly, identifying as a woman does not imply a greater vulnerability to energy poverty. However, looking at gendered household types, being a single mother and a man living alone is

associated with greater odds of being energy poor. Therefore, gendered household configurations, rather than gender emerges as a significant energy poverty factor.

Overall, the vulnerable customers' characteristics identified are living in an energy inefficient accommodation, experiencing an increase in households' energy demands, limited housing supply choice, being a renter, lower educational level, being unemployed or inactive, living in a big household, living alone, being a single mother and being a man living alone.

Chapter 4 - Energy poverty: outcomes and gendered household types

The European Parliament has identified 5 energy poverty outcomes: physical health, mental health, social stigma, disconnection, and cost of living (figure 1). Based on their operationalization (table 4), the first aim of this chapter is to determine the association between these outcomes and energy poverty, controlling for alternative explanations (figure 8). Additionally, the European Parliament framed gender as a factor interacting with each outcome. As the driver analysis evidenced, gendered household configurations were shown to be more relevant when considering energy poverty factors (chapter 3). Thus, for each outcome, the second model explores the interaction between gender, household types, and energy poverty (figures 9-10-11).

For each outcome, the socio-economic and demographic covariates identified in the literature (see annex 8) are included in the European Parliament energy poverty framework, except for migration background. They have been operationalized (table 3) and included as controls in Models 1-2-3. Additionally, since this analysis aims at exploring the interaction between energy poverty factors and outcomes, it implies controlling for alternative explanations. Therefore, Models 4-5 control for energy poverty drivers, as defined and operationalized in Chapter 2.1.

4.1 – Energy poverty outcomes

4.1.1 – Methodology

For each outcome, an OLS regression is conducted, following Model 4. It measures whether being in energy poverty (EPi) predicts variation in each outcome (Yi), controlling for energy poverty drivers (Zi).

Model 4: Multivariate regression - outcomes on energy poverty

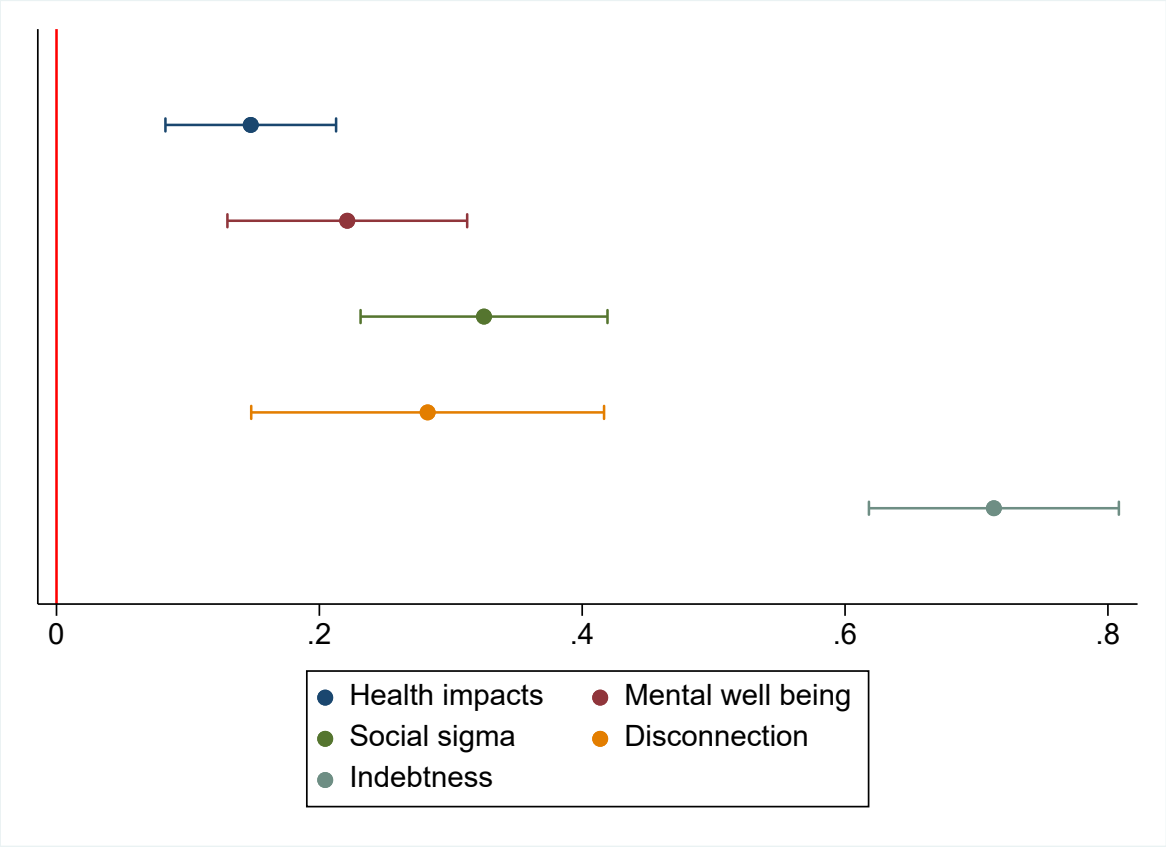
$$Yi = \beta 0i + \beta i\ EPi + \beta i\ Zi + uij + \varepsilon i$$

with: Uij: country fixed effect

4.1.2 – Results and interpretation

For each outcome, a separate regression has been run, following Model 4. The output of each regression is reported in Figure 8. Controls and country-fixed effects are not reported for visualization clarity, but the full regression outputs are available in the annex (see annex 9).

Figure 8: Regressions coefficients - energy poverty outcomes



Source: Author's own calculation, based on Eurofound's Living, Working and COVID-19 e-survey (Spring 2022)
Note: Independent regressions have been run for each outcome, controlling for energy poverty drivers (energy demand & use, physical infrastructure, individual characteristics) and gender, with country-fixed effects. Interpretation: coefficient below 0 is associated with an in the outcome (bettering), while coefficient above 0 is associated with a decrease in the outcome (worsening)

Being in energy poverty is associated with a significant worsening of each outcome, even when controlling for energy poverty drivers. Being in energy poverty implies the widest increase in indebtedness levels. Yet, it is to note that energy poverty is measured from an expenditure perspective (table 1), which may explain its stronger association with economic variables. Regarding societal exclusion, being in energy poverty is associated with increased feelings of social stigma and disconnection. Lastly, regarding health outcomes, being in energy poverty is associated with a significant increase in the likelihood of reporting poor mental and physical health.

4.2 – Energy poverty outcomes and gendered household types

4.2.1 – Methodology

For each outcome (Yi), a regression is conducted following Model 5. The objective is to quantify the association between gender (Xi), household type (Ci), and energy poverty (Epi). The model controls for energy poverty drivers (Zi) and country fixed effects (uij) are included.

Model 5: Multivariate regression - energy poverty outcomes on the interaction between gendered household types and energy poverty

$$Yi = \beta 0i + \beta 1\ EPi\#Xi\#Ci + \beta i\ Zi + uij + \varepsilon i$$

with EPi#Xi#Ci: interaction between respondent i energy poverty status, gender, and household type

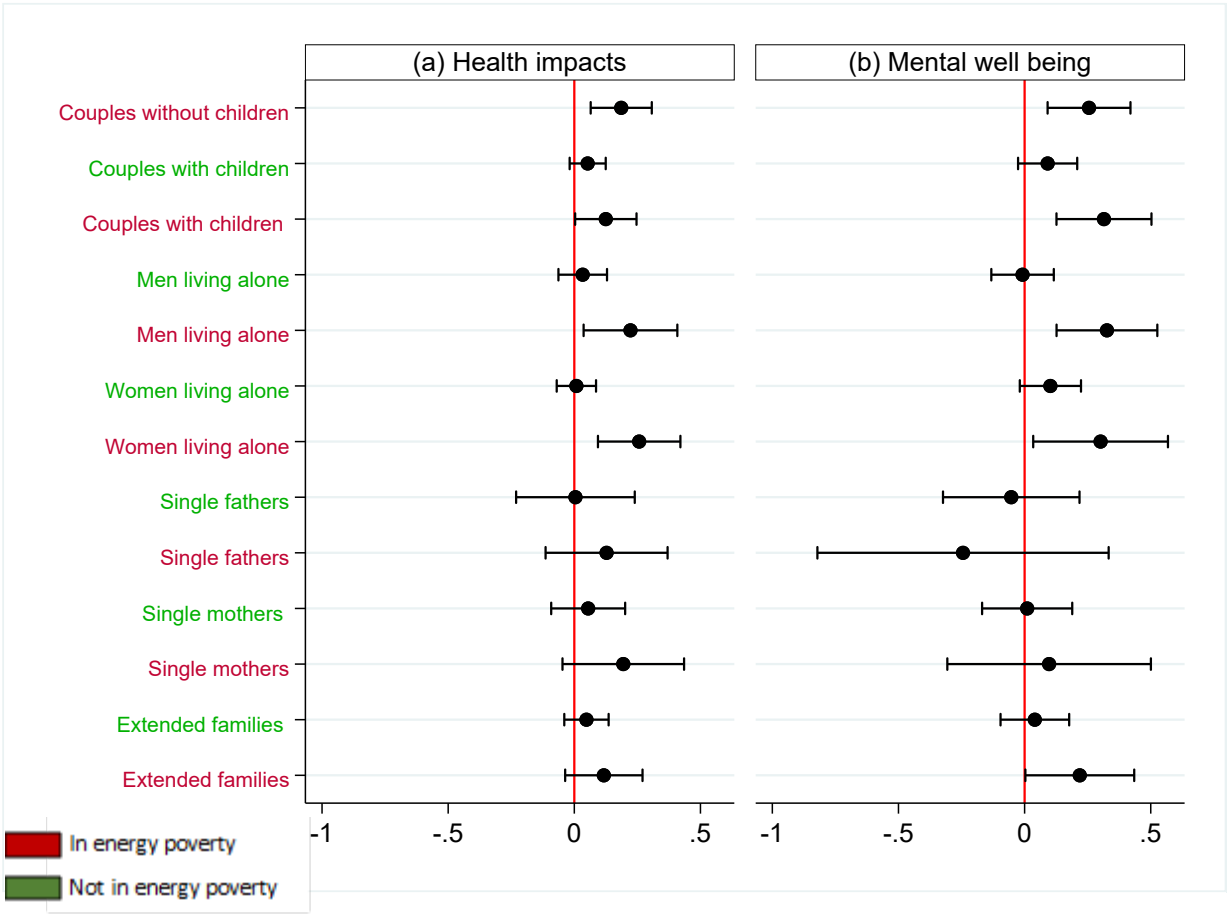
4.2.2 – Results and interpretation

For each outcome, a separate regression has been run, following Model 5. The full regression outputs, including controls and country-fixed effects, are available in the annex (annex 10). The variables coding is available in Table 4.

Health

Figure 9(a) depicts the regression coefficients predicting a variation in physical health as a function of the interaction between gendered household types and energy poverty. Figure 9(b) presents the regression results of the interaction between gender, household type, and energy poverty on mental well-being.

Figure 9: Regression coefficients - health outcomes



Source: Author's own calculation, based on Eurofound's Living, Working and COVID-19 e-survey (Spring 2022)

Note: Independent regressions have been run for health impacts and mental wellbeing, following Model 5. Regressions control for energy poverty drivers (energy demand & use, physical infrastructure, individual characteristics). Country-fixed effects have been included. The baseline for household type is couples without children, not in energy poverty.
Interpretation: coefficient below 0 is associated with a decrease in the outcome (bettering) and a coefficient below 0 with a decrease (worsening)

Gendered household types not in energy poverty

For both health outcomes, when not in energy poverty, gendered household types are not significant predictors of health outcomes.

Gendered household types in energy poverty

When energy poor, couples without children, couples with children, and both men and women living alone are associated with a significant decline in physical and mental health. Additionally, living in an extended family and being energy poor is associated with a significant decrease in mental well-being (b).

Both men and women living alone are associated with a decline in health outcomes when in energy poverty. However, the confidence intervals of both gendered household configurations overlap. It signifies that, when in energy poverty, household types, rather than gender, are influencing health outcomes.

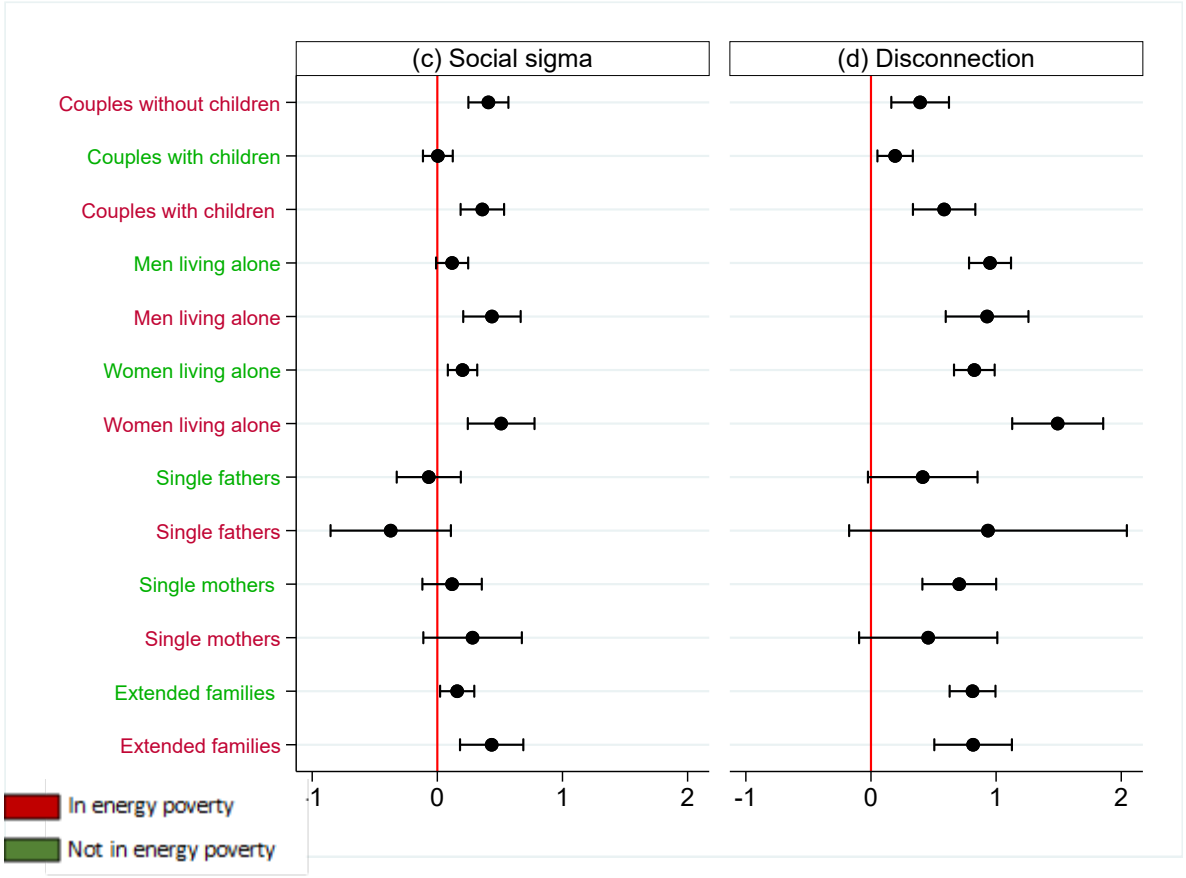
Comparing gendered household types not and in energy poverty

Comparing the association between similar household configurations and health outcomes, when they are and are not in energy poverty, revealed that all follow the same pattern. In fact, if none of the gendered household types are associated with a significant worsening of health outcomes when they are not in energy poverty, most are when they are in energy poverty.

Societal exclusion

Figure 10(c) depicts the regression coefficients predicting a variation in social stigma as a function of the interaction between gendered household types and energy poverty. Social stigma is measured by respondents feeling left out of society (table 4). Figure 10(d) presents the coefficients from the regression of the interaction between gendered household types and energy poverty on disconnection. Disconnection is measured by respondents feeling of loneliness (table 4).

Figure 10: Regression coefficients - societal exclusion



Source: Author's own calculation, based on Eurofound's Living, Working and COVID-19 e-survey (Spring 2022)
Note: Independent regressions have been run for social stigma and disconnection, following Model 5. Regressions control for energy poverty drivers (energy demand & use, physical infrastructure, individual characteristics). Country-fixed effects have been included. The baseline for household type is couples without children, not in energy poverty.
Interpretation: coefficient below 0 is associated with an in the outcome (bettering), while coefficient above 0 is associated with a decrease in the outcome (worsening)

Gendered household types not in energy poverty

Firstly, considering the association between gendered household types, not in energy poverty, and social stigma, women living alone and individuals in extended families are associated with a significant increase in their feeling of social exclusion (c). Secondly, considering the association between gendered household types, not in energy poverty, and disconnection, couples with children, men, and women living alone, single mothers, and extended families are associated with a significant increase in feeling disconnected (d). Especially, living alone is the household type associated with the strongest increase in disconnection.

For social stigma, identifying as a woman living alone is associated with a significant increase in the outcome, while this is not the case for men living alone (c). For disconnection, identifying as a single mother is associated with a significant increase in the outcome, while this is not the case for single

fathers (d). Therefore, for societal exclusion outcome, both a gendered and household effect is identifiable, when individuals are not in energy poverty.

Gendered household types in energy poverty

Considering gendered household types in energy poverty, couples with and without children, men and women living alone, and extended families are associated with a significant increase in feeling stigmatized and disconnected (c and d).

Comparing gendered household types by energy poverty status

Comparing the association between similar gendered household types and societal exclusion outcomes, when they are and are not in energy poverty, revealed 3 different situations.

Firstly, as for health outcomes (figure 9), some household types are only associated with a significant worsening of outcomes when they are in energy poverty. For social stigma (c) it is the case for couples with children and men living alone.

Secondly, some gendered household types, which are already associated with a significant worsening of outcomes when they are not in energy poverty, are associated with an even stronger decline when they are energy poor. This is the case for women living alone and extended families, both associated with a wider increase in feeling stigmatized when they are in energy poverty, compared to when they are not (c). Similarly, couples with children and women living alone are significantly associated with a wider increase in feeling disconnected when they are not in energy poverty (d). Also, couples without children are associated with a significant increase in perceived societal exclusion when in energy poverty, compared to couples without children, not in energy poverty, the baseline category of the interaction term (c and d).

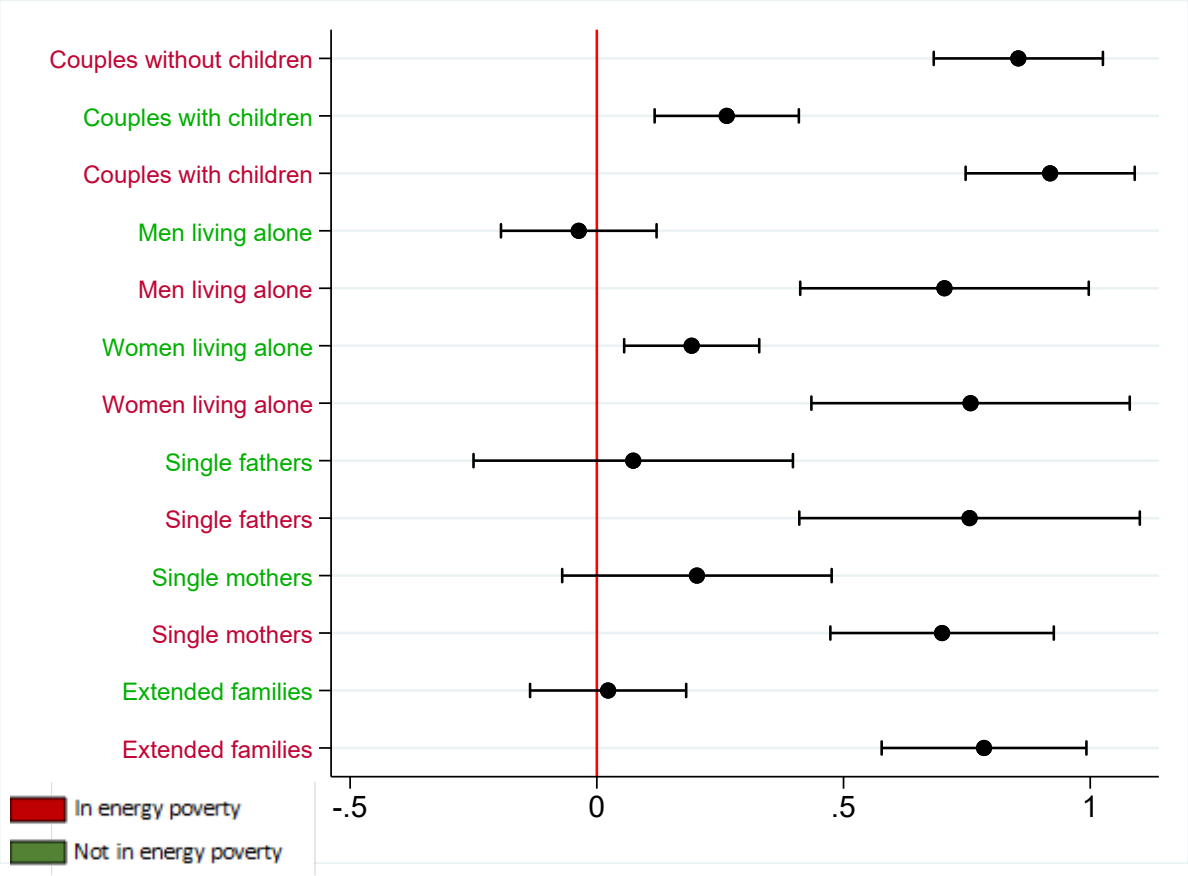
Thirdly, other gendered household types are associated with a significant worsening of outcomes when both in and not in energy poverty. However, being in energy poverty, by comparison to not being in energy poverty, does not imply a systematic worsening of outcomes, as the coefficients' confidence intervals intersect when they are and are not in energy poverty. This is the case for disconnection for men living alone and extended families (d).

Lastly, single mothers are associated with a significant increase in feeling disconnected when they are in energy poverty, but this association is no longer significant when they are in energy poverty.

Indebtedness

Figure 11 depicts the regression coefficients predicting a variation in indebtedness level as a function of the interaction between gendered household types and energy poverty. Savings levels are used as a proxy for indebtedness (table 4).

Figure 11: regression coefficients - indebtedness



Source: Author's own calculation, based on Eurofound's Living, Working and COVID-19 e-survey (Spring 2022)
Note: visualization from Model 5 for indebtedness. The regression controls for energy poverty drivers (energy demand & use, physical infrastructure, individual characteristics), with country-fixed effects. The baseline for household type is couples without children, not in energy poverty.
Interpretation: coefficient below 0 is associated with an in the outcome (bettering), while coefficient above 0 is associated with a decrease in the outcome (worsening)

Gendered household types not in energy poverty

When not in energy poverty, couples with children and women living alone are associated with a higher indebtedness level, compared to couples without children. Therefore, both gender and household effects are identifiable.

Gendered household types not in energy poverty

When in energy poverty, every gendered household type is associated with a significant increase in debts. Especially, couples with and without children are associated with the largest decrease in savings.

Comparing gendered household types by energy poverty status

Comparing the association between similar gendered household types and societal exclusion outcomes, when they are and are not in energy poverty, revealed 2 different situations.

Firstly, men living alone, single fathers, single mothers, and extended families are associated only with a significant increase in indebtedness level, only when in energy poverty. No gender effect is found, as the confidence intervals of single fathers and mothers overlap.

Secondly, some gendered household types are associated with a significant increase in indebtedness level when they are not in energy poverty, and with an even stronger one when they are in energy poverty. This is the case for couples with and without children and for women living alone.

Summary: energy poverty outcomes and gendered household types

Energy poverty outcomes are multi-dimensional. In fact, being in energy poverty is associated with a greater likelihood of having poor physical and mental health, increase feelings of loneliness and disconnection and higher indebtedness levels.

The analysis of figures 9-11 reveals that for each outcome, couples with and without children, men and women living alone, and extended families (except for physical health) in energy poverty are associated with a significant increase in experiencing adverse outcomes. Among these gendered household types, some are not at risk of experiencing adverse outcomes when they are not in energy poverty. For these gendered household types energy poverty constitute a new vulnerability. Other household types were already at greater risk of facing adverse outcomes when not in energy poverty, and this risk further increases when they are in energy poverty. For these gendered household configurations, energy poverty constitutes an additional vulnerability. Especially, for women living alone, energy poverty constitutes an additional vulnerability when it comes to social stigma, disconnection, and indebtedness. Therefore, energy poverty as a new vulnerability is driven by household types while energy poverty as an additional vulnerability is driven by gender. Table 5 provides a summary of the results.

Table 5: Gendered household types, energy poverty, and its outcomes

Gendered household types….	… when not in energy poverty	… when in energy poverty	
Women living alone	When not in energy poverty, households are associated with a worsening of outcomes	When in energy poverty, households are associated with a worsening of outcomes	**Gender effect:** Energy poverty as an **additional vulnerability**
Couple without children Couple with children Men living alone Extended families	When not in energy poverty, households are not associated with a worsening of outcomes	When in energy poverty, households are associated with a worsening of outcomes	**Household effect:** Energy poverty is a **new vulnerability**

Conclusion

Skyrocketed inflation and Russia's weaponization of its energy led to increased energy bills. It posed a challenge for European households: surviving winter. Yet, households differ in their ability to cope with energy poverty. From mapping the share of the population in arrears with their utility bills, in Europe, in Spring 2022, the strongest rates are found among women (figure 2) and single parents (figure 3). To understand gendered households types' vulnerability to energy poverty, this paper offered an engendered analysis of energy poverty factors, drivers, and outcomes. The analysis is based on the operationalization of the European Parliament framework (figure 1) using the LWC dataset.

Energy poverty lacks a common European definition. The review of existing Member States' definitions revealed 2 main common elements: the relativity of energy poverty depending on households' needs and its economic centrality. Thus, for the purpose of analysis, energy poverty was defined and measured by a household's being in arrears with its utility bills (table 1).

Energy poverty factors are defined as individuals' characteristics whose systematic and specific interactions with energy poverty drivers and outcomes produced biased consequences. From the engendered review of the literature, gender, ethnicity, household types, and gendered household types were identified as energy poverty factors and, except for ethnicity, operationalized (table 2).

Energy poverty drivers are elements affecting energy affordability. They are grouped into 4 main categories: country drivers, energy demand & use & expenditures, physical infrastructure, and socio-demographic drivers (table 3). Based on their partial operationalization (figure 4), a logit regression model evidenced that building efficiency, energy demands, supply choice, building tenure, employment status, educational level, income, age, and household size were significant energy poverty drivers (figure 4).

Gendered household types imply an additional vulnerability to energy poverty. Single parents (figure 5), and especially single mothers and men living alone (figure 6) are associated with greater odds of being in energy poverty, controlling for energy poverty drivers.

Energy poverty outcomes vary if households' energy poverty status changes, all things being equal. The 5 energy poverty outcomes: health, mental wellbeing, social stigma, disconnection, and savings, identified by the European Parliament were operationalized using the LWC dataset (table 4). All were evidenced to significantly worsen if an individual is experiencing energy poverty (figure 8).

Energy poverty affects differently gendered household types' vulnerability towards health, societal exclusion, and indebtedness. For couples without and with children, men living alone, and extended families, energy poverty is a new vulnerability. It implies that these gendered household types are associated with a significant decrease in most outcomes only when energy poor, controlling for energy poverty drivers. For women living alone, energy poverty is an additional vulnerability. It signifies that women living alone are associated with a decline in the outcomes (except health), when not in energy poverty, and an even greater decrease when they are energy poor.

Energy poverty is a multi-dimensional issue, in both its driver and outcomes. Yet, income remains the main predictor of energy poverty (figure 5) while being in energy poverty implies the greatest variation in indebtedness levels (figure 8). Following the war in Ukraine, every Member State has implemented short-term support measures to help citizens pay their utility bills. through tax credits, subsidies, cost compensations, and price caps (EU PolicyWatch, 2023). However, only 10 Member States have targeted their energy support measures to low-income households: Slovakia, Estonia, Germany, Greece, the Netherlands, Finland, Slovenia, Hungary, Poland, and Denmark (EU PolicyWatch, 2023).

To eradicate energy poverty, long-term policies improving the energy efficiency of buildings and appliances, in a gender-aware way, are necessary. At the European level, the Renovation Wave invests in the renovation of worst-performing private and public buildings. At the Member States level, subsidies or support enabling households to improve their housing or appliances' energy efficiency have been provided (EU PolicyWatch, 2023). Yet, most measures are gender-blind and tackle energy efficiency as part of the European Green Deal. It leads to policies focusing on households' energy sources: green energy in Norway, solar installations in Bulgaria, Slovenia, and Hungary, and electrification subsidies in Finland. However, poor households are often forced to use unsustainable and unhealthy energy sources (Anagnostopoulos and De Groote, 2016). It implies that the long-term energy poverty alleviation measures tend to be targeted at better-off households, despite income being the stronger predictor of being in energy poverty.

Gendered household type, rather than gender, is associated with vulnerability to energy poverty. As each household type is affected differently by energy poverty, policies should be mindful of their target population. Especially, single parents, more likely to be in energy poverty, and women living alone, more likely to be negatively affected by energy poverty outcomes, should be given special attention. Yet, looking at Member States, 5 have targeted their energy poverty policies towards couples with children (Latvia, Germany, Austria, Romania, and Greece) and only Greece has targeted single parents (EU Policy Watch).

Therefore, the engendered analysis of energy poverty factors, drivers, and outcomes revealed that policies concerned with utility bills payments helped households to survive winter. Yet, their survival in the following winters will require the preservation of short-term policies and their combination with long-term ones. As energy poverty is a multi-dimensional issue, its alleviation requires gender-aware energy efficiency improvement policies. When implemented to reach the Green Deal objectives, policies should be conscious of the reality experienced by energy poor households. As energy poverty affects gendered household types differently, policies should be mindful of their target population and devote particular attention to single mothers and women living alone.

Annex

Annex 1: correlation between income and energy poverty

	Income	Energy poverty
Income	1.0000	
Energy poverty	0.2016	1.0000

Interpretation: correlation coefficient ranges from 1 (perfect positive relationship) to -1 (perfect negative relationship). 0 indicates no relationship between the variables.

Annex 2: Original variables from LWC and recoding

	E-survey question	E-survey scale	Recoding
Gender	*How would you describe yourself?*	Categorical variable, with 1: male 2: female 3: in another way	Categorical variable, with 1: men, 2: women
Household types	*Are there any children or young people aged less than 25 in your household?*	Binary variable, with 0: no 1: yes	1: no children/young people but spouse/partner in the household 2: children/young people and spouse/partner in the household 3: one person only usually live in the household 4: children/young people but no spouse/partner in the household 5: parent/grandparent living in the household
	Do you have a spouse/partner that lives in your household?	Binary variable, with 0: no 1: yes	
	Do you have a parent or grandparent that lives in your household?	Binary variable, with 0: no 1: yes	
	Including yourself, can you please tell me how many people usually live in your household?	Continuous variable, with scale from 1-10+	
Building Efficiency	*Thinking about your accommodation, how problematic is poor insulation/energy?*	Continuous variable, from 1: not at all problematic to 5: extremely problematic	Binary variable, with 0: not at all problematic, not problematic, neither problematic nor unproblematic and 1: slightly problematic, extremely problematic
Energy Demands	*Compared to before the pandemic, how has the importance of sufficient insulation and energy*	Continuous variable, from 1: much less importance to 5: much more important	Binary variable, with 0: much less important, less important, neither more nor less important and 1: more

	efficiency in your housing, changed for you?		important, much more important
Supply Choice	*How satisfied are you with your accommodation?*	Continuous variable, from 1: very dissatisfied to 10: very satisfied	Binary variable, with 0: ranking from 5 to 10 and 1: ranking from 1 to 4
Building Stock	*Which of the below best describes your accommodation?*	Categorical variable, with 1: detached house, 2: semi-detached house 3: terraced house 4: apartment, flat, bedsit 5: other	Binary variable, with 0: detached house, semi-detached house, terraced house and 1: apartment, flat, bedsit, other
Network Access	*Would you consider the area in which you live to be...?*	Categorical variable, with 1: open countryside, 2: village/small town, 3: medium to large town, 4: city or city suburb	Categorical variable, with 1: open countryside 2: village/small town, medium to large town 3: city or city suburb
Building Tenure	*Which of the following best describes your accommodation?*	Categorical variable, with 1: owned without mortgage, 2: owned with mortgage, 3: rented from social/municipal/non-profit provider, 4: rented from private landlord or company 5: other	Binary variable, with 0: owned without mortgage, owned with mortgage and 1: rented from social/municipal/non-profit provider, from private landlord or company, other
Dwelling Size	*Thinking about your accommodation, how problematic is the lack of space for you?*	Continuous variable, from 1: not at all problematic to 5: extremely problematic	Binary variable, with 0: not at all problematic, not problematic, neither problematic nor unproblematic and 1: slightly problematic, extremely problematic
Employment Status	*Which of these categories best describes your situation?*	Categorical variable, with 1: employee, 2: self-employed with employees, 3: self-employed without employees, 4: unemployed, 5: unable to work due to long-term illness or disability, 6: retired, 7: full-time homemaker/fulfilling domestic tasks, 8: student	Categorical variable, with 1: employee, self-employed with employees, self-employed without employees 2: unemployed 3: unable to work, retired, full-time homemaker 4: student
Education Level	*What is the highest level of education you completed (according to ISCED categories)?*	Categorical variable, with 1: primary or less 2: lower secondary 3: secondary 4: post-secondary non-tertiary 5: short-cycle tertiary 6: Bachelor 7: Master 8: PhD	Categorical variable, with 1: primary or less, lower secondary, 2: secondary, post-secondary non-tertiary, 3: short-cycle tertiary, Bachelor, Master, PhD

Disability	*Do you have any chronic (long-standing) physical or mental health problem, illness, or disability?*	Binary variable, with 0: no and 1: yes	
Income	*What is your household's total net income per month?*	Continuous variable, with income brackets in 10 categories, calculated at the country level based on deciles (from EU-SILC) and presented in local currencies.	Continuous variable, with 1: brackets 9-10 (top 25%) 2: brackets 7-8 3: brackets 4-6 4: brackets 1-3 (bottom 25%)
Age	*How old are you?*	Continuous variable, from 18 to 98 years old	
Household size	*Including yourself, can you please tell me how many people usually live in your household?*	Continuous variable, from 1 to 10 or more	
Health impacts	*In general, how is your health?*	Continuous variable, 1: very good 2: good 3: fair 4: bad 5: very bad	
Mental well being	*Mental well-being index, computed from respondents' agreement with the following statements: I have felt cheerful and in good spirits, I have felt calm and relax, I have felt active and vigorous, I woke up feeling fresh and rested, my daily life has been filled with things that interest me*	Continuous variable with index from 1: very bad mental health to 100: very good mental health	Continuous variable, with 1: index from 80-100 2: index from 60-80 3: index from 40-60 4: index from 40-20 5: index 0-20
Social sigma	*To what extent do you agree or disagree with the statement: I feel left out of society*	Continuous variable, with scale from 1: strongly agree 2: agree 3: neither agree nor disagree 4: disagree 5: strongly disagree	Continuous variable, with scale from 1: strongly disagree 2: disagree 3: neither agree nor disagree 4: agree 5: strongly agree
Disconnection	*Please indicate which statement is closest to how you have been feeling over the last two weeks: I have felt lonely*	Continuous variable with scale from 1: all the time 2: most time 3: more than half the time 4: less than half the time 5: sometimes 6: at no time	Continuous variable with scale from 1: at no time 2: sometimes 3: less than half the time 4: more than half the time 5: most time 6: all the time
Indebtness	*If your household would not receive any income,*	Continuous variable, with scale from 1: no savings 2:	Continuous variable, with scale from 1: 12+ months 2:

	how long would your household be able to maintain the same standard of living using savings?	less than 3 months 3: 3-6 months 4: 6-12 months 5: 12+ months	6-12 months 3: 3-6 months 4: less than 3 months 5: no saivings

Annex 3: variance inflation factors between energy poverty drivers

Energy poverty	VIF	1/VIF
Building efficiency	1.23	0.815396
Energy demands	1.14	0.875904
Supply choice	1.16	0.859874
Building stock (baseline: MHF)	1.4	0.712844
Network access (baseline: cities)	1.44	0.692219
Towns	1.55	0.645038
Countryside		
Building tenure (baseline: owner)	1.4	0.715133
Dwelling size	1.18	0.845436
Non-income vulnerability: employment status (baseline: employed) - Unemployed	1.16	0.861631
Inactive	1.17	0.853792
Retired	2.27	0.44039
Student	1.25	0.800612
Non-income vulnerability: educational level (baseline: lower than secondary education)	2.22	0.450831
Secondary education	2.32	0.431182
Tertiary education		
Disability (baseline: no disability)	1.11	0.9013
Income	1.33	0.753769
Age	2.57	0.389268
Household size	1.24	0.808577
Country fixed effects (baseline: Austria)	2.21	0.451602
Belgium	1.77	0.564905
Bulgaria	1.47	0.681408
Croatia	1.1	0.911925
Cyprus	2.13	0.469547
Czechia	1.63	0.613282
Denmark	1.15	0.869157
Finland	1.59	0.627816
France	6.78	0.147507
Germany	8.39	0.119195
Greece	2.23	0.44934
Hungary	2.12	0.470944
Ireland	1.53	0.655075
Italy	6.72	0.148822
Latvia	1.2	0.830991
Lithuania	1.31	0.762672
Luxembourg	1.01	0.986948
Malta	1.06	0.940375

Netherlands	2.63	0.37999
Poland	4.71	0.212357
Portugal	2.15	0.464971
Romania	3.07	0.325976
Slovakia	1.42	0.704966
Slovenia	1.23	0.80981
Spain	5.51	0.18145
Sweden	2.1	0.475952
Mean VIF	**2.17**	

Interpretation: VIF below 5 indicates a low correlation, VIF between 5 and 10 indicates a high correlation, VIF above 10 indicates multicollinearity

Annex 4: logit regression results - odds of energy poverty by drivers, with country fixed-effects (Model 1)

Energy poverty	Odds ratio [95% confidence interval]
Building efficiency	1.49*** [1.23 1.82]
Energy demands	1.31** [1.08 1.59]
Supply choice	1.57*** [1.23 2.01]
Building stock (baseline: MHF)	1.17 [0.95 1.44]
Network access (baseline: cities)	1.15 [0.94 1.40]
Towns	1.12 [0.81 1.55]
Countryside	1.25* [1.01 1.54]
Building tenure (baseline: owner)	1.03 [1.33 2.35]
Dwelling size	1.03*** [1.33 2.35]
Non-income vulnerability: employment status (baseline: employed)	1.44* [1.08 1.93]
Unemployed	0.72* [0.54 0.95]
Inactive	0.54* [0.32 0.89]
Retired	0.72** [0.56 0.92]
Student	0.50*** [0.39 0.65]
Non-income vulnerability: educational level (baseline: lower than secondary education)	1.00 [0.83 1.20]
Secondary education	1.73*** [1.57 1.91]
Tertiary education	
Disability (baseline: no disability)	
Income	

Age	1.00 [0.99 1.00]
Household size	1.23*** [1.51 1.33]
Country fixed effects (baseline: Austria)	
Belgium	2.06***
Bulgaria	4.17***
Croatia	3.54***
Cyprus	5.76***
Czechia	1.25
Denmark	.73
Finland	1.08
France	2.97***
Germany	1.94***
Greece	.80
Hungary	8.57***
Ireland	2.07***
Italy	1.41
Latvia	2.91***
Lithuania	2.23***
Luxembourg	1.59*
Malta	5.52***
Netherlands	3.15***
Poland	1.12
Portugal	1.46
Romania	1.55
Slovakia	6.89***
Slovenia	1.50
Spain	2.06 ***
Sweden	1.02
	.80
Constant	0.01*** [0.01 0.02]

** p<0.05, ** p<0.01, *** p<0.001*

Annex 5: Logit regression results - odds of energy poverty by gender and household types, controlling for energy poverty drivers and with country fixed-effects (Model 2)

Energy poverty	Odds ratio [95% confidence interval]	Odds ratio [95% confidence interval]
Women (baseline: men)	0.93 [0.78 1.11]	0.89 [0.74 1.07]
Household types (baseline: couple without children)		1.23
Couple with children		[0.89 1.70]
Living alone		1.35
Single parents		[0.99 1.83]
Extended family		1.52 *
		[1.03 2.25]
		0.92

		[0.63 1.34]
Building efficiency	1.49***	1.49***
	[1.23 1.82]	[1.21 1.82]
Energy demands	1.33**	1.32**
	[1.09 1.61]	[1.08 1.61]
Supply choice	1.56***	1.53**
	[1.22 2.00]	[1.18 1.97]
Building stock (baseline: MHF)	1.16	1.22
	[0.95 1.42]	[0.98 1.52]
Network access (baseline: cities)	1.12	1.15
Towns	[0.81 1.42]	[0.93 1.42]
Countryside	1.12	1.08
	[0.81 1.56]	[0.77 1.50]
Building tenure (baseline: owner)	1.26*	1.24*
	[1.02 1.55]	[1.00 1.54]
Dwelling size	1.04	1.03
	[0.81 1.33]	[0.80 1.33]
Employment status (baseline: employed)	1.77***	1.97***
Unemployed	[1.33 2.35]	[1.47 2.65]
Inactive	1.47*	1.50**
Retired	[1.10 1.97]	[1.11 2.03]
Student	0.73*	0.75
	[0.55 0.97]	[0.56 1.02]
	0.54*	0.60
	[0.33 0.89]	[0.35 1.01]
Educational level (baseline: lower than secondary education)	0.72**	0.74*
	[0.56 0.92]	[0.57 0.96]
Secondary education	0.50***	0.52***
Tertiary education	[0.39 0.65]	[0.40 0.68]
Disability (baseline: no disability)	1.00	1.01
	[0.83 1.20]	[0.84 1.22]
Income	1.74***	1.73***
	[1.57 1.92]	[1.55 1.93]
Age	1.00	1.00
	[0.99 1.00]	[0.99 1.00]
Household size	1.24***	1.26***
	[1.11 1.33]	[1.13 1.42]

Country fixed effects (baseline: Austria)		
Belgium	2.05***	2.05**
Bulgaria	4.21***	4.66***
Croatia	3.60***	3.74***
Cyprus	5.69***	6.06***
Czechia	1.22	1.29
Denmark	.73	0.70
Finland	1.09	1.17
France	2.96***	2.99***
Germany	1.94**	1.96**
Greece	.80	0.79
Hungary	8.63***	9.32***
Ireland	2.11***	2.25***
Italy	1.37	1.40
Latvia	2.92***	3.11***
Lithuania	2.25***	2.33***
Luxembourg	1.61*	1.61
Malta	5.60***	5.61***
Netherlands	3.17***	3.55***
Poland	1.08	1.08
Portugal	1.48	1.59
Romania	1.56	1.46
Slovakia	6.93***	7.27***
Slovenia	1.48	1.63*
Spain	2.06***	2.24***
Sweden	1.02	1.15
	.80	0.79
Constant	0.01***	0.01***
	[0.01 0.02]	[0.00 0.02]

** p<0.05, ** p<0.01, *** p<0.001*

Annex 6: Logit regression null results - odds of energy poverty by gender, with country fixed-effects (Model 2)

Energy poverty	Odds ratio [95% confidence interval]
Women (baseline: men)	1.07 [0.92 1.25]

Country fixed effects (baseline: Austria)	1.87**
Belgium	3.06***
Bulgaria	3.06***
Croatia	5.36***
Cyprus	0.8
Czechia	0.59*
Denmark	0.86
Finland	2.19***
France	1.67**
Germany	0.73
Greece	8.39***
Hungary	1.35
Ireland	1.36
Italy	2.72***
Latvia	2.01***
Lithuania	1.20
Luxembourg	1.49
Malta	1.05
Netherlands	0.82
Poland	1.42
Portugal	1.61*
Romania	2.42***
Slovakia	1.42
Slovenia	1.67**
Spain	1.08
Sweden	0.66

Annex 7: logit regression results - odds of energy poverty by gendered household types, controlling for energy poverty drivers and with country fixed-effects (Model 3)

Energy poverty	Odds ratio [95% confidence interval]
Gendered household configurations (baseline: couple without children)	1.24
Couple with children	[0.9 1.71]
Men living alone	1.63**
Women living alone	[1.14 2.34]
Single fathers	1.14
Single mothers	[0.80 1.62]
Extended family	1.14
	[0.59 2.22]
	1.61*
	[1.06 2.36]
	0.93
	[0.64 1.36]
Building efficiency	1.50***
	[1.23 1.84]
Energy demands	1.32**
	[1.08 1.61]
Supply choice	1.52**
	[1.17 1.95]
Building stock (baseline: MHF)	1.21
	[0.98 1.52]
Network access (baseline: cities)	1.14
Towns	[0.93 1.41]
Countryside	1.06
	[0.76 1.48]
Building tenure (baseline: owner)	1.24
	[0.99 1.54]
Dwelling size	1.03
	[0.80 1.33]
Non-income vulnerability: employment status (baseline: employed)	1.96***
Unemployed	[1.46 2.63]
Inactive	1.46*
Retired	[1.8 1.97]
Student	0.76
	[0.56 1.03]
	0.61
	[0.36 1.03]
Non-income vulnerability: educational level (baseline: lower than secondary education)	0.74*
	[0.57 0.96]
Secondary education	0.52***
Tertiary education	[0.39 0.67]
Disability (baseline: no disability)	1.01
	[0.84 1.22]
Income	1.73***
	[1.55 1.93]
Age	1.00

	[0.99 1.01]
Household size	1.27*** [1.14 1.42]
Country fixed effects (baseline: Austria)	
Belgium	2.09***
Bulgaria	4.69***
Croatia	3.69***
Cyprus	6.25***
Czechia	1.30
Denmark	0.71
Finland	1.17
France	3.03***
Germany	1.97**
Greece	0.80
Hungary	9.35***
Ireland	2.25***
Italy	1.42
Latvia	3.14***
Lithuania	2.34***
Luxembourg	1.61
Malta	5.55***
Netherlands	3.59***
Poland	1.10
Portugal	1.61
Romania	1.46
Slovakia	7.32***
Slovenia	1.62*
Spain	2.28***
Sweden	1.16
	0.80
Constant	0.01*** [0.00 0.02]

Annex 8: Usual controls for physical health, mental health, societal sigma, and indebtedness, by research sources

Outcomes	Controls	Source
Physical Health	Education level Gender Age Employment status Disability Household Size Urbanization degree	Eurofound (2022). Economic and social inequalities in Europe in the aftermath of the COVID-19 pandemic. p.42

Mental Health	Education level Gender Age Partner Children Country	Toffolutti V, Plach S, Maksimovic T, Piccitto G, Mascherini M, Mencarini L, Aassve A. The association between COVID-19 policy responses and mental well-being: Evidence from 28 European countries. Social Science Med.
Societal Exclusion	Gender Age Chronic illness Urbanization degree Migrant Education level Employment status Income	Eurofound (2022). Social cohesion and well-being in Europe. p.15 Nb: lack of data availability for migration status
Indebtedness	Household type Employment status Education level Age Urbanization degree	Eurofound (2022). Economic and social inequalities in Europe in the aftermath of the COVID-19 pandemic. p.24

Annex 9: OLS regression results - energy poverty outcomes by energy poverty, controlling for energy poverty drivers and with country fixed-effects (Model 4)

	Health	Mental well being	Social exclusion	Disconnection	Indebtness
Energy poverty	0.148***	0.221***	0.325***	0.282***	0.713***
Building efficiency	0.067*	0.158***	0.110**	0.055	0.156***
Energy demands	0.059*	0.091**	0.20	0.098*	-0.048
Supply choice	0.275***	0.454***	0.453***	0.647***	0.170**
Building stock (baseline: MHF)	0.018	0.016	0.012	-0.051	0.019
Network access (baseline: cities)	0.072**	0.067	0.119***	0.081	0.075
Towns	0.038	0.042	0.187**	0.076	0.066
Countryside					
Building tenure (baseline: owner)	0.032	0.086*	0.075*	0.151**	0.455***
Dwelling size	0.038	0.227***	0.083	0.073	0.102*
Employment (baseline: employed)	0.120*	0.079	0.495***	0.360***	0.06
Unemployed	0.442***	0.248***	0.357***	0.297**	-0.016
Inactive	0.098**	-0.007	0.198***	0.188**	-0.207***
Retired	-0.074	-0.081	-0.279***	0.357**	-0.0201*
Student					
Education (baseline: > secondary)	-0.036	-0.052	-0.133*	-0.203**	-0.154**
Secondary	-0.087*	-0.122*	-0.299***	-0.181*	-0.484***
Tertiary					
Disability (baseline: no disability)	0.744***	0.240***	0.157***	0.243***	0.169***
Income	0.052***	0.086***	0.097***	0.150***	0.313***
Age	0.004***	-0.003	-0.009***	-0.008***	-0.003*
Household size	-0.013	0.007	0.001	-0.064***	0.104***
Women (baseline: men)	-0.007	0.136***	0.015	0.140***	0.107**

Country fixed effects (baseline: Austria)	0.056	0.137	0.318***	0.152	-0.074
Belgium	0.032	0.122	0.657***	0.403***	0.719***
Bulgaria	0.081	0.118	0.407***	0.026	0.465***
Croatia	-0.229***	0.379***	0.481***	0.276*	0.147
Cyprus	0.056	0.113	0.073	-0.027	0.229***
Czechia	0.158**	-0.080	0.085	-0.161	-0.068
Denmark	0.191***	0.159*	0.405***	0.208*	0.353***
Finland	0.061	0.046	0.268***	0.221*	0.258***
France	0.113*	0.185*	0.428***	0.385***	0.117
Germany	0.027	0.092	0.164*	0.167	0.087
Greece	-0.219***	0.359***	0.289***	0.433***	0.302***
Hungary	0.149**	0.021	0.784***	-0.013	0.411***
Ireland	-0.029	0.190**	0.530***	0.206*	0.169*
Italy	0.048	0.338***	0.191**	0.471***	-0.346***
Latvia	0.347***	0.262***	0.064	-0.049	0.665***
Lithuania	0.329***	0.111	0.483***	0.070	0.684***
Luxembourg	0.101	0.239*	0.330***	0.359**	0.277*
Malta	-0.001	0.339***	0.836***	0.425**	0.293*
Netherlands	0.051	0.021	0.445***	-0.036	0.069
Poland	0.205***	0.457***	0.464***	0.466***	0.539***
Portugal	0.252***	0.257***	-0.059	0.332**	0.163*
Romania	0.436***	0.461***	0.608***	0.550***	0.978***
Slovakia	0.139**	0.127	0.306***	0.037	0.375***
Slovenia	0.051	-0.105	0.416***	-0.175	0.347***
Spain	-0.135***	0.038	0.290***	-0.014	-0.055
Sweden	0.312***	0.255***	0.237***	0.282**	-0.106
Constant	1.544***	2.240***	2.131***	2.101***	2.020***

Annex 10: OLS regression results - energy poverty by gendered household types and energy poverty, controlling for energy poverty drivers and with country fixed-effects (Model 5)

	Health	Mental well being	Social exclusion	Disconnection	Indebtness
Couple without children…..	0.186**	0.255**	0.408***	0.393***	0.854***
….in energy poverty					
Couple with children….	0.053	0.091	0.004	0.193**	0.263***
….not in energy poverty	0.125*	0.315**	0.360***	0.585***	0.919***
….in energy poverty					
Men living alone…					
…not in energy poverty	0.033	-0.008	0.118	0.951***	-0.037
….in energy poverty	0.223*	0.326**	0.436***	0.928***	0.705***
Women living alone…					
….not in energy poverty	0.008	0.102	0.201***	0.826***	0.192**
…in energy poverty	0.257**	0.301*	0.510***	1.492***	0.757***
Single fathers…					
…not in energy poverty	0.005	-0.053	-0.068	0.414	0.074
….in energy poverty	0.128	-0.244	-0.373	0.935	0.755***

Single mothers…					
….not in energy poverty	0.055	0.010	0.118	0.706***	0.203
….in energy poverty	0.194	0.097	0.282	0.457	0.700***
Extended families…					
….not in energy poverty	0.048	0.041	0.159*	0.812***	0.023
….in energy poverty	0.117	0.219*	0.434***	0.816***	0.785***
Building efficiency	0.064*	0.163***	0.121**	0.079	0.152***
Energy demands	0.067**	0.091**	0.018	0.097*	-0.044
Supply choice	0.272***	0.449***	0.436***	0.595***	0.169**
Building stock (baseline: MHF)	0.014	0.022	0.023	-0.023	0.032
Network access (baseline: cities)	0.074**	0.060	0.123***	0.083	0.065
Towns	0.029	0.023	0.188**	0.027	0.060
Countryside					
Building tenure (baseline: owner)	0.036	0.095*	0.070	0.094	0.452***
Dwelling size	0.040	0.240***	0.096*	0.099	0.109*
Employment (baseline: employed)	0.145**	0.099	0.533***	0.355***	0.039
- Unemployed	0.447***	0.295***	0.364***	0.359***	0.013
Inactive	0.105**	0.005	0.196***	0.207**	-0.163**
Retired	-0.077	-0.064	-0.290***	0.159	-0.173
Student					
Education (baseline: lower than secondary education)	-0.026	-0.054	-0.107	-0.202**	-0.160**
Secondary education	-0.078*	-0.109*	-0.276***	-0.172*	-0.483***
Tertiary education					
Disability (baseline: no)	0.743***	0.336***	0.154***	0.220***	0.175***
Income	0.049***	0.086***	0.086***	0.089***	0.318***
Age	0.005***	-0.003	-0.008***	-0.006**	-0.004*
Household size	-0.015	0.003	0.021	-0.008	0.081*
Country fixed effects (baseline: Austria)	0.077	0.133	0.324***	0.141	-0.083
Belgium	0.034	0.103	0.614***	0.311**	0.729***
Bulgaria	0.088	0.104	0.378***	-0.095	0.480***
Croatia	-0.214***	0.367***	0.465***	0.288*	0.172
Cyprus	0.051	0.091	0.050	-0.081	0.231**
Czechia	0.154**	-0.086	0.078	-0.183	-0.076
Denmark	0.193***	0.152*	0.374***	0.168	0.366***
Finland	0.061	0.032	0.260***	0.197*	0.253***
France	0.104	0.164*	0.421***	0.356***	0.120
Germany	0.023	0.083	0.168*	0.199*	0.084
Greece	-0.219***	0.349***	0.268***	0.418***	0.305***
Hungary	0.139**	0.007	0.754***	-0.079	0.428***
Ireland	-0.029	0.177**	0.505***	0.178	0.197*
Italy	0.040	0.320***	0.158*	0.414***	-0.326***
Latvia	0.350***	0.257***	0.034	-0.112	0.676***
Lithuania	0.325***	0.115	0.466***	0.028	0.695***
Luxembourg	0.112	0.234*	0.275*	0.237	0.292**
Malta	-0.008	0.340***	0.807***	0.316*	0.316*
Netherlands	0.066	-0.023	0.404***	-0.115	0.078
Poland	0.201***	0.443***	0.436***	0.290*	0.553***

Portugal	0.239***	0.240**	-0.097	0.258*	0.157
Romania	0.439***	0.430***	0.556***	0.431***	1.000***
Slovakia	0.145**	0.115	0.299***	-0.005	0.407***
Slovenia	0.055	-0.085	0.366***	-0.245	0.372***
Spain	-0.130*	-0.011	0.261**	-0.040**	-0.034
Sweden	0.325***	0.252***	0.240**	0.285***	-0.129
Constant	1.496***	2.260***	1.999***	1.687***	2.010***

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The European Foundation for the Improvement of Living and Working Conditions (Eurofound) is a tripartite European Union Agency established in 1975. Its role is to provide knowledge in the area of social, employment and work-related policies according to Regulation (EU) 2019/127.