Energy Poverty and Subjective Well-being Revisited: Insights from the German Socio-Economic Panel

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Abstract

This paper examines the impact of energy poverty on life satisfaction, drawing on data from the German Socio-Economic Panel (2010–2021). The findings show that energy poverty significantly diminishes life satisfaction, particularly through subjective perceptions of household energy inadequacy. The paper highlights the importance of multidimensional strategies to tackle energy poverty and its profound impact on well-being.

1. Introduction

Energy poverty – a multidimensional concept describing the inability of households to secure adequate energy services – has increasingly captured attention in both policy and academic circles. Once seen as a developing-country issue, energy poverty is now a growing concern in advanced economies (Bouzarovski, 2014). Particularly for Germany, its ambitious commitment to the *Energiewende* – transition to a sustainable energy system – has significantly reshaped its energy landscape. While crucial for climate goals, this transition has raised challenges around energy affordability and equitable access. The integration of renewable energy sources, coupled with rising costs, disproportionately impacts low-income households, making energy poverty a critical social issue in Germany with significant implications for individual well-being.

The relationship between energy poverty and subjective well-being (SWB) is multifaceted. Energy poverty can contribute to material deprivation, social exclusion, and adverse health outcomes, all of which can negatively impact life satisfaction (Liddell et al., 2012). Moreover, the psychological burden associated with energy poverty – such as the stress and anxiety caused by high energy bills or the inability to maintain a comfortably warm home – can further diminish an individual's SWB.

This paper utilizes the German Socio-Economic Panel (SOEP) dataset to revisit the relationship between energy poverty and self-assessed life satisfaction, employing both objective and subjective measures. Analyzing data from approximately 70,499 individuals (2010–2021), we find that energy poverty significantly diminishes life satisfaction, with the reduction ranging from 0.02 to 0.29 points on an 11-point scale. The negative effect is more pronounced when measured subjectively, with self-reported energy poverty. Importantly, this impact persists even after controlling for income, indicating that energy poverty is a distinct issue, not merely a byproduct of income poverty.

Our analysis adds to the growing literature on the social implications of energy poverty in high-income countries, where energy affordability is an increasingly urgent concern. Unlike previous studies for Germany, such as Biermann (2016), which focused on heating expenditures from 1994 to 2013, our analysis incorporates more recent data and accounts for both electricity and heating costs. This approach provides a more comprehensive and up-to-date evaluation of energy poverty's impact on life satisfaction. Our findings highlight the need to address energy poverty through broader social and economic policies to improve overall quality of life.

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2. Data & Empirical Strategy

We use data from the German SOEP, a nationally representative household survey covering 1984 to 2021, including households from all federal states, as well as foreigners, migrants, and refugees. The survey provides detailed information on socio-economic status, demographics, energy costs, education, and well-being. Its longitudinal nature enables the analysis of trends over time, such as changes in energy poverty. For the analysis, we focus on the period from 2010 to 2021, as 2010 marks the first year that electricity expenditure data was included.

Overall life satisfaction: We measure subjective well-being through overall life satisfaction, assessed by asking respondents to rate their satisfaction with life on a scale from 0 to 10, where 0 represents complete dissatisfaction and 10 represents complete satisfaction. Figure 1a shows the trend in average life satisfaction over time, suggesting that there are no significant differences between males and females, except in 2015-2017, where men report lower life satisfaction.

Energy Poverty Indicators Our main explanatory variables include both objective (expenditure-based) and subjective (consensual-based) indicators of energy poverty. The objective indicators are the *10% rule, 2-median share (2M), and low-income high-cost (LIHC)* (Meyer et al., 2018; Nie & Li, 2023). These expenditure-based indicators are calculated using monthly household income and energy costs, specifically heating and electricity expenses. We adjust for household size and composition using the OECD-modified equivalence scale, which accounts for economies of scale, allowing for more accurate comparisons across households of different sizes.

- **10% Rule**: classifies households as energy-poor if they spend more than 10% of their equivalized income on energy.

- **2M Share**: The 2M Share indicator, suggested by the European Poverty Observatory (Thema & Vondung, 2020), calculates the national median share of equivalized energy expenditure as a percentage of income for each year. A household is considered energy-poor if it spends more than twice this median share.
- **LIHC**: The LIHC indicator (Hills, 2012), identifies energy-poor households based on two criteria: low income (LI) and high energy costs (HC). A household is classified as low income if its disposable income, after energy expenses, falls below 60% of the national median income. High energy costs are defined as energy expenditures at or above the national median. A household is considered energy-poor if it meets both conditions, reflecting vulnerability due to both financial constraints and high energy expenses.
- **Consensual**: The consensual indicator is a subjectively-based measure, emanating from two questions which assesses whether households can adequately heat their home during cold months and if the reason for the inadequate warmth is due to financial reasons. These questions were introduced into the SOEP survey from 2016.
- **Composite**: We compute a composite indicator that combines both expenditure-based and consensual approaches to measure energy poverty more comprehensively. It is a binary indicator, coded as 1 if an individual is considered energy-poor by at least two indicators, such as the 10% Rule, 2M Share, LIHC, or subjective measures like difficulty in heating the home adequately.

Figure 1b shows the share of individuals identified as energy-poor across five indicators. The expenditure-based measures exhibit wide volatility and high levels of energy poverty over the years. In contrast, the Consensual indicator, based on subjective experiences, shows fewer individuals reporting an inability to heat their homes, and highlights a gap between subjective reports and expenditure-based measures, which may capture hidden forms of energy poverty. The Composite indicator combines multiple dimensions, and remains relatively stable around 10%, smoothing out fluctuations and reflecting long-term trends. These varying stabilities demonstrate the importance of a multidimensional approach to fully capture the complexity of energy poverty.

Table 1 presents the average monthly equivalized income, energy expenditure, and proportion of energy-poor individuals across income deciles, with D1 representing the lowest-income group, and D10 the highest. The results show stark contrasts between income classes. The top decile (D10) enjoys the highest income and spends only 3% on energy, reflecting a low financial burden. Conversely, the lowest decile (D1) spends about 13% of their income on energy, highlighting a substantial financial strain. These findings illustrate the disproportionate impact of energy costs on lower-income households, making them more vulnerable to energy poverty. While energy poverty is most prevalent among the lowest-income group, it also affects some higher-income households, indicating that the issue extends beyond income disparities.

Covariates: The literature on SWB suggests that individual well-being primarily depends on the "*big four*" factors: wealth, health, social relations, and genes. Accordingly, we include variables reflecting these determinants. Our explanatory variables encompass socioeconomic factors (log of income, income poverty indicator, log of peer income, employment status, and education level), demographics (age, household composition, location, and housing conditions), and health indicators (poor health, chronic illness, or disability) (Clark et al., 2008; Welsch, 2024).
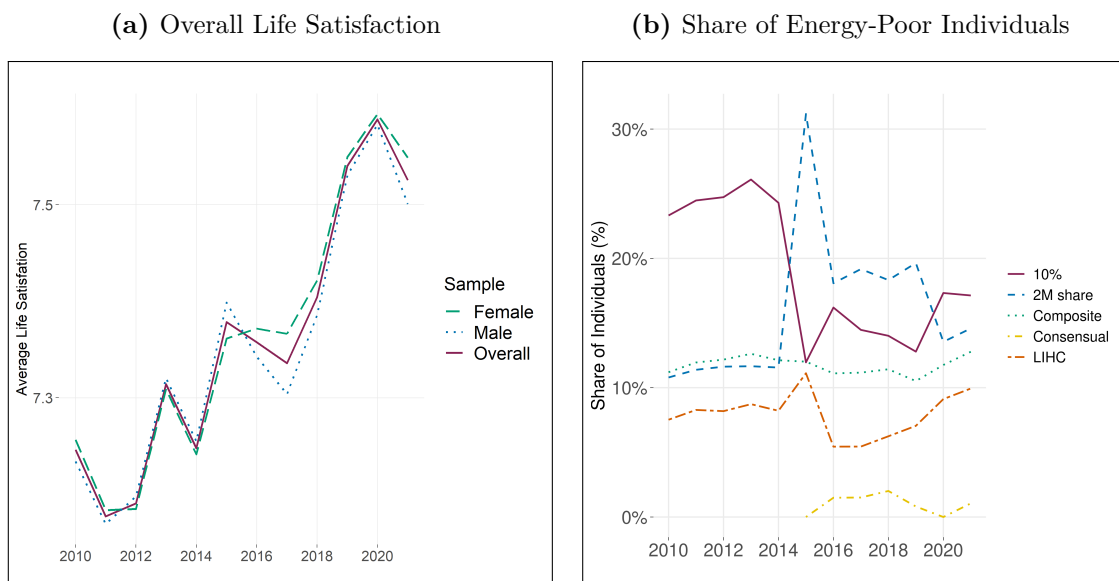
(a) Overall Life Satisfaction

(b) Share of Energy-Poor Individuals

Figure 1: Trends in Overall Life Satisfaction and Energy Poverty Indicators

Table 1: Average Monthly Equivalized Income, Energy Expenditure, and Share of energy-poor across Income Groups (2010-2021 Pooled Sample)

Averages of Variables	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Monthly Equivalised Income	539.27	831.31	1025.17	1210.68	1405.29	1608.94	1872.87	2197.97	2659.63	4657.37
Electricity Cost	21.68	35.37	37.34	38.17	38.82	39.91	41.37	41.46	43.05	49.52
Heating Cost	27.91	47.17	51.01	53.77	55.64	55.95	59.90	60.42	63.78	76.42
Total Cost	49.59	82.53	88.36	91.94	94.46	95.86	101.26	101.88	106.83	125.94
Share of income spent on energy (%)	12.85	9.96	8.64	7.61	6.73	5.96	5.42	4.64	4.03	3.09
Energy Poverty Indicators	Percentage Share of Individuals in the Sample									
10%	44.59	49.50	33.85	23.30	14.79	9.55	6.56	2.96	1.81	0.65
2M Share	38.45	39.41	27.09	19.79	14.21	8.96	6.59	3.54	1.95	0.75
LIHC	27.41	42.38	9.52	0.76	0.03	0.00	0.00	0.00	0.00	0.00
Consensual	2.85	4.63	3.33	1.77	1.14	0.68	0.62	0.48	0.27	0.10
Composite	28.06	40.04	12.88	7.82	7.71	7.24	6.51	3.23	1.98	0.77

Notes: The total number of individuals in our sample is 70,499. For the Consensual indicator, the number of individuals is 45,694 ..

Empirical Strategy: We estimate self-reported life satisfaction *LS* of individual *i* in year *t*. The equation is as follows:

$$LS_{it} = \beta_{1}^{a}\mathbf{EP}_{it(a)} + \delta\mathbf{SE}_{it}' + \phi\mathbf{D}_{it}' + \lambda\mathbf{H}_{it}' + \theta\mathbf{TI} + \gamma_t + \gamma_r + \gamma_{ih} + \varepsilon_{it} \tag{1}$$

where *LS* represents the self-reported life satisfaction of individual *i* in year *t*. $EP_{it(a)}$ in Equation (1) captures the impact of energy poverty on SWB, with *a* representing different energy poverty indicators: *a* = {10%, 2M, LIHC, Consensual, Composite}. The vector $\mathbf{SE}_{it}'$ contains individual-level socio-economic controls such income poverty, log of income, log of peer income, employment status, and educational level. Vector $\mathbf{D}_{it}'$ denotes demographic variables including age, household types, and urban residence. The vector $\mathbf{H}_{it}'$ includes whether the individual has a poor health, disability or chronic illness, and $\mathbf{TI}_{it}'$ captures the presence of thermal insulation in the dwelling. γ_t represents survey year fixed effects while γ_r captures state-specific factors through state fixed effects. γ_{ih} includes individual *i* × household *h* fixed effects, accounting for unobserved heterogeneity both the individual level (e.g., personality traits) and the household level. ε_{it} is the idiosyncratic error term. Standard errors are clustered at the individual level for all regressions.

3. Results

Table 2 presents the fixed effects regression results, examining how various factors, including energy poverty, impact SWB, measured by life satisfaction. The analysis high-lights several important determinants of life satisfaction beyond energy poverty. Income plays a crucial role, with personal income positively correlated with life satisfaction. Additionally, being income-poor has a detrimental effect on life satisfaction.

Conversely, higher peer income – reflecting relative income comparisons – is associated with lower life satisfaction. Remarkably, the magnitude of this comparison effect is consistently larger than the positive effect of one's own income across different specifications. This suggests that absolute income plays a minimal role in determining life satisfaction, underscoring the significance of social comparisons in well-being. In terms

of policy implications, these findings suggest that equal absolute increases in income – such as those implied by equal-per-capita rebates from carbon pricing revenues – are unlikely to enhance SWB. Instead, addressing relative income disparities may be more crucial for improving life satisfaction.

The results show that individuals with poor health, disability, or chronic illness report significantly lower life satisfaction, underscoring crucial role of health factors in well-being. Employment status also plays a significant role: unemployment consistently reduces life satisfaction by 0.108 to 0.118 points, likely due to the loss of social interactions at work, as income effects are controlled for. In contrast, retirement is linked to higher life satisfaction, likely due to financial security and increased leisure time, which can enhance social relationships and reduce stress.

We find mixed effects for education: individuals without a degree report higher life satisfaction than those with secondary education, while no significant difference is found between secondary and tertiary education levels. This suggests a more complex relationship between education and well-being. The results also show that household composition also matters for SWB. We find that individuals in partnerships or multi-generational households report higher satisfaction than those living alone. Conversely, single parents experience significantly lower life satisfaction, likely due to financial and caregiving burdens. Urban residents generally report higher life satisfaction than rural residents, likely due to better access to facilities, healthcare, and job opportunities. Interestingly, age shows no consistent impact on life satisfaction, and thermal insulation in homes does not consistently correlate with higher life satisfaction, except in one model, indicating that while it may add comfort, it is not a decisive factor in overall well-being. Turning to the central focus of this paper, energy poverty is shown to have a significant and

Table 2: Energy Poverty and Subjective well-being – Baseline Estimates

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Life Satisfaction				
	10% Rule	2M Share	LIHC	Consensual	Composite
Energy Poverty	-0.0353***	-0.0217**	-0.0261	-0.2853***	-0.0486***
	(0.0098)	(0.0095)	(0.0171)	(0.0500)	(0.0116)
Income poverty	-0.0946***	-0.0995***	-0.0898***	-0.0667***	-0.0841***
	(0.0135)	(0.0134)	(0.0160)	(0.0238)	(0.0141)
ln(Income)	0.0989***	0.1019***	0.1077***	0.1108***	0.1054***
	(0.0128)	(0.0127)	(0.0126)	(0.0221)	(0.0126)
ln(Peer income)	-0.5152***	-0.5174***	-0.5222***	-1.888***	-0.5146***
	(0.1321)	(0.1322)	(0.1321)	(0.2410)	(0.1321)
Poor health	-0.7416***	-0.7415***	-0.7417***	-0.6988***	-0.7414***
	(0.0111)	(0.0111)	(0.0111)	(0.0179)	(0.0111)
Chronic illness	-0.0465***	-0.0467***	-0.0466***	-0.0638***	-0.0467***
	(0.0077)	(0.0077)	(0.0077)	(0.0136)	(0.0077)
Disability	-0.1058***	-0.1057***	-0.1057***	-0.0686**	-0.1054***
	(0.0204)	(0.0205)	(0.0204)	(0.0335)	(0.0204)
Education level					
Secondary	Ref	Ref	Ref	Ref	Ref
No degree	0.1795***	0.1796***	0.1794***	0.0347	0.1797***
	(0.0333)	(0.0333)	(0.0333)	(0.0695)	(0.0333)
Tertiary degree	-0.0493	-0.0496	-0.0491	0.0693	-0.0491
	(0.0357)	(0.0357)	(0.0357)	(0.0626)	(0.0357)
Employment status					
Employed (self)	Ref	Ref	Ref	Ref	Ref
Non-working	-0.1177***	-0.1178***	-0.1178***	-0.1082***	-0.1181***
	(0.0122)	(0.0122)	(0.0122)	(0.0216)	(0.0122)
Retired	0.1485***	0.1487***	0.1487***	0.0737**	0.1490***
	(0.0193)	(0.0193)	(0.0193)	(0.0328)	(0.0193)
Age	-0.5844	-0.5870	-0.5866	0.1752	-0.5722
	(669.9)	(670.2)	(670.4)	(1,384.3)	(669.5)
Household types					
Single Household	Ref	Ref	Ref	Ref	Ref
Couple without kids	0.2845***	0.2845***	0.2837***	0.3857***	0.2807***
	(0.0248)	(0.0248)	(0.0248)	(0.0436)	(0.0248)
Single parents	-0.1429***	-0.1439***	-0.1444***	0.0124	-0.1469***
	(0.0315)	(0.0315)	(0.0315)	(0.0568)	(0.0315)
Couple with kids	0.2109***	0.2105***	0.2091***	0.3440***	0.2054***
	(0.0265)	(0.0265)	(0.0265)	(0.0475)	(0.0265)
Other household	0.1067***	0.1069***	0.1054***	0.1696**	0.1008**
	(0.0399)	(0.0399)	(0.0399)	(0.0689)	(0.0399)
Urban	0.0815**	0.0815**	0.0817**	0.1948***	0.0817**
	(0.0412)	(0.0412)	(0.0412)	(0.0694)	(0.0412)
Thermal insulation	-0.0134	-0.0142	-0.0138	0.0334***	-0.0144
	(0.0087)	(0.0087)	(0.0087)	(0.0128)	(0.0087)
Number of Individuals	70,499	70,499	70,499	45,694	70,499
Number of Households	41,683	41,683	41,683	27,684	41,683
Within R^2	0.03634	0.03630	0.03629	0.03293	0.03637
Observations	331,071	331,071	331,071	133,900	331,071
Year FE	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓
Household × Individual FE	✓	✓	✓	✓	✓

Notes: The data is from SOEP version 38. The dependent variable is Overall life satisfaction (scale 0-10: 0=Completely dissatisfied, 10=Completely satisfied). The column labels represents the measure for energy poverty. Each column comes from a unique regression.

Peer income is computed by first calculating the median monthly equivalence household income of reference groups based on age, gender, education level, and region. The mean (equivalised household) income of the four respective reference groups is then computed as an individual's peers' average income.

Clustered standard errors at the individual level are shown in parentheses. *: Significant at the 10% level. **: Significant at the 5% level. ***: Significant at the 1% level.

negative impact on life satisfaction. Most energy poverty indicators, including the 10% Rule, 2M Share, composite indicators show statistically significant negative effects on life satisfaction, with reductions ranging from 0.022 to 0.285 points on the 11-point scale. The Consensual indicator, which captures subjective experiences of difficulty in heating the home, has the most substantial impact, reducing life satisfaction by 0.29 points. This highlights the significant emotional and psychological toll of energy poverty, where subjective perceptions of energy deprivation are strongly linked to lower well-being. Notably, these effects remain significant even after controlling for income levels and income poverty, indicating that energy poverty imposes an additional burden on life satisfaction, beyond what can be explained by income poverty alone. This finding challenges the traditional view that energy poverty is merely a subset of income poverty, and demonstrate that it is a distinct and significant factor affecting individuals' well-being.

4. Conclusion

This paper revisits the relationship between energy poverty and subjective well-being using data from the German Socio-Economic Panel (2010–2021). The findings reveal that energy poverty significantly reduces life satisfaction, especially when measured subjectively through indicators like the Consensual measure, which captures self-reported difficulties in heating homes. This negative impact persists even after controlling for income, indicating that energy poverty is a distinct issue that profoundly affects well-being. These results highlight the importance of considering both objective and subjective dimensions when assessing energy poverty, as each offers unique insights into the lived experiences of those affected. Our findings also highlight the role of personal income and relative income comparisons in life satisfaction, emphasizing the importance of social

comparisons. These results underscore the need for targeted policy interventions that address both income disparities and the specific challenges of energy poverty to improve the quality of life for vulnerable populations in Germany.

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