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# Characterizing the energy use of disabled people in the European Union towards inclusion in the energy transition

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**Designing environmental policy to take account of social difference is increasingly recognized as essential to address both effectiveness and justice concerns. So far there is limited research on the experiences of disabled people in the environmental literature, amounting to a failure to recognize this substantial constituency. Here we compare disabled households' embodied energy use, income, risk of poverty and energy poverty, and other socio-demographics with other households in the European Union. We find that households including an economically inactive disabled person earn less and consume 10% less energy than other households, and are more likely to experience energy poverty. Disabled households have lower consumption than other households in most categories, with the exception of basic consumption such as food, energy at home (gas and electricity), water and waste services: in effect they have less—and sometimes inadequate—access to resources. We conclude that more attention should be paid to disabled households needs to ensure a just energy transition.**

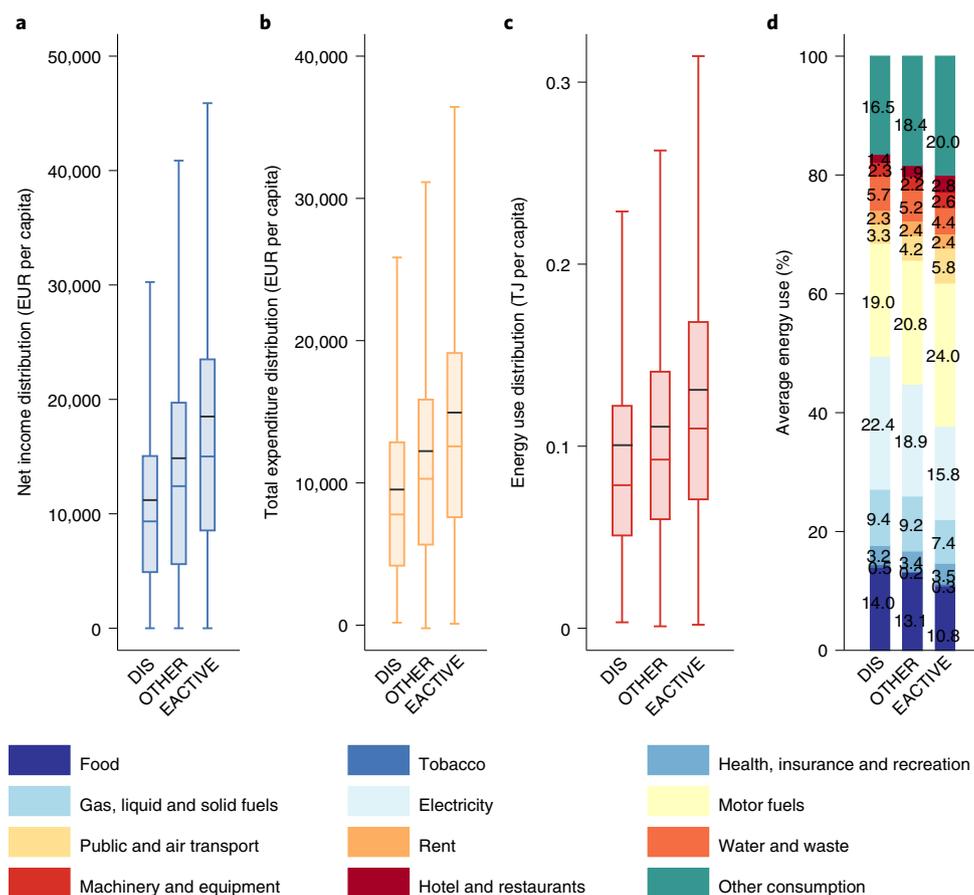
Recent work on sustainable consumption argues for a more nuanced approach to policy, taking into account a range of social differences when planning and delivering interventions<sup>1–6</sup>. Given the substantial differences in consumption levels associated with affluence<sup>7</sup>, the wide variation of energy use in wealthy nations more generally<sup>8,9</sup> and the differential impact of the effects of climate change on different people, it is important to understand the differences in what people are able to consume when considering how to address a transition to a more sustainable future. In the emerging literature on social difference, scholars pay attention to populations that experience injustice, pointing out that the interests and experiences of women, people from ethnic minorities, working class and disabled people are poorly accounted for in environmental policy and research. Taking account of social difference in environmental policy and practice is both a matter of effectiveness (to avoid addressing people with policies that they will not be able to engage in) and justice (offering fair options for people who have particular needs).

So far there is very limited research on the needs and experiences of disabled people in the environmental literature<sup>4,10–15</sup>. Note that we have chosen to use identity-first language here, both in naming these disabled households and referring to disabled people. This is the way in which disabled activists refer to disabled people in the United Kingdom, where we are based; we wish to support their choice in this and do not intend to cause harm (see <https://disabilityunion.co.uk/person-first-or-identity-first-the-importance-of-language> for more information). Disabled people are subject to a failure in recognition justice: they are largely invisible in environmental policy and practice, and rarely discussed as having particular needs or facing particular challenges in a transition towards a more sustainable future. This is despite the fact that disabled people are regularly supported by their governments in developed nations (including European Union (EU) nations) and seen as important targets of social policy. When we consider that of the 446 million people living in the EU, around 100 million are believed to be disabled<sup>16</sup>, this is by no means a rare experience, and disability is a topic that merits more attention

from environmental scholars and policymakers. Disabled people may also be more vulnerable to climate change consequences such as extreme temperatures or emergency relief being inaccessible<sup>12</sup>.

Disabled people's experiences are diverse and disabled people will live very different lifestyles<sup>17–19</sup>. The concept of disability is a very broad one, and can include a wide range of impairments such as autism spectrum conditions, long-term health conditions, mental health conditions, physical or mobility impairments, sensory impairments (for example, deafness and blindness) and learning difficulties<sup>20</sup>. Although some disabilities are life-long, others develop during the course of life and, as such, can present challenges for everyday living as people have to adapt to a new impairment and the changes in lifestyle that this necessitates. When considering transitions to less environmentally impactful futures, an inclusive approach will involve understanding the diverse impacts that disability has on people's energy use and requirements.

There are, however, some common trends in disabled people's lives that are well recognized and will have clear energy implications. Disabled people on average earn less than non-disabled people<sup>18</sup>, and their energy use is likely to be lower than average given that income is by far the primary driver of carbon and energy footprints<sup>7</sup>. Some disabled people will find it harder to access employment, education and social opportunities<sup>21</sup>, which will also impact on their energy use. People in poor health certainly travel less<sup>22</sup> and, as such, are likely to have higher requirements for energy in the home. Some disabled people will have specific needs to use energy: higher room temperature, use of electrical equipment or access to a car<sup>21,23</sup>. People with disabilities tend to have higher health-care expenditure and health needs<sup>18</sup>, yet they are also less likely to access health services and are more likely to have worse health and wellbeing outcomes<sup>18</sup>. Studies on disability and energy poverty show that a combination of low income levels and high energy needs results in more disabled people being unable to afford adequate energy services, often exacerbating their disability as a result<sup>21,23</sup>. Furthermore, there is a strong connection between people in poor health and energy poverty in most EU nations<sup>24</sup>.

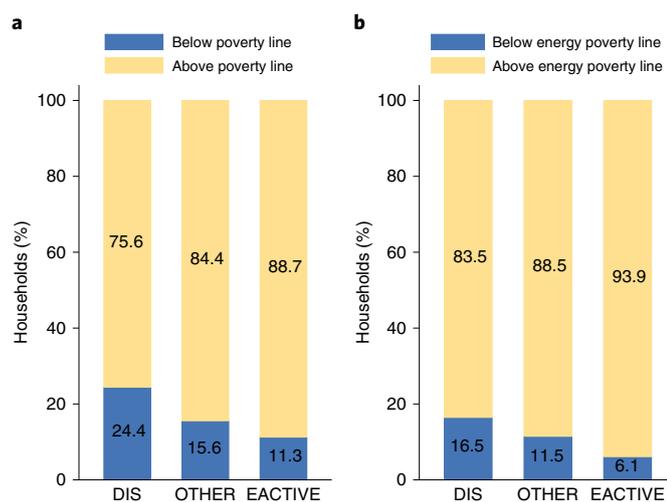


**Fig. 1 | Income, expenditure and energy use distributions by household type in the EU.** **a**, Annual net household income distribution in euro (EUR) per capita including non-monetary remunerations and excluding income tax. **b**, Annual household consumption expenditure distribution measured in EUR per capita. **c**, Annual energy use distribution including home energy, transport energy and energy embodied in consumption measured in terajoules per capita. **d**, Average energy use by consumption category in percentages summing to 100% for each type of household (see legend for colour coding). Household types: DIS, household with a disabled and economically inactive member; OTHER, household with economically inactive member for reasons other than permanent disability; EACTIVE, household with only economically active members. The lines within the boxes represent the medians (in the colour of the boxes) and means (in black), whereas the boxes themselves describe the 25th (bottom hinge) and 75th (top hinge) percentiles. The top/bottom whiskers reflect the maximum/minimum if there are no outliers ( $\pm 1.5$  times the interquartile range); in cases of outliers, they describe the highest/lowest values within 1.5 times the interquartile range of the previous value. The box plots exclude all outliers. Sample sizes for **a**, excluding Italy due to lack of income data, are as follows: DIS, 7,319; OTHER, 93,003; EACTIVE, 52,186. Sample sizes for **b–d**: DIS, 7,722; OTHER, 107,746; EACTIVE, 59,498. Supplementary Figs. 2 and 3 contain the energy, income and expenditure distributions within the total and disability samples, and by country.

Given these trends, we can expect that disabled people will use less energy, but this is not necessarily through choice: indeed it is likely to be at the cost of disabled people not having their needs for energy and other resources met. Energy is not purchased for its own sake, but for the energy services that it delivers<sup>25</sup>; some energy services are essential for wellbeing and survival as in the case of cooking, heating and access to health and education infrastructure<sup>8</sup>. Although access to adequate energy services has clear wellbeing implications, research exploring the energy use of disabled people and the implications for energy poverty is scarce. In this study we provide a comprehensive quantitative analysis of the energy use of disabled households in the EU in various consumption domains including transport, housing, food, health services and other consumption. We use the term disabled household throughout to mean a household with at least one disabled and economically inactive member. This category captures people unable to work due to a physical or other disability and excludes disabled people who are economically active or who fit into another category of economic inactivity such as children, retired or in full-time education. Given that economically inactive disabled people are more likely to have

more substantial impairments, and to suffer from material deprivation and poverty compared with employed disabled people<sup>26–28</sup>, our analysis of energy use, poverty and other social indicators among economically inactive disabled people in the EU is still extremely policy relevant, even if not representative of all disabled people. We consider both home energy (where use of energy in final consumption can help perform actions directly such as lighting, cooking, heating and cooling) and energy embodied in consumption (which is required to provide goods and services such as food, clothing and communication)<sup>25</sup>.

In this study we quantify household energy use on the basis of household consumption data from Eurostat's household budget surveys (HBS) and energy intensities from EXIOBASE. Both data sources reflect trends in 2010, which is the latest available Eurostat wave at the time of submitting this article. First, we explore the energy use of disabled households in comparison to other households, highlighting differences in consumption across various consumption categories. Through a multivariate regression analysis, we estimate that disabled households have 10% lower energy use, which is associated with lower consumption of transport, health and



**Fig. 2 | Risk of poverty and energy poverty by household type in the EU.**

**a.** Households living below the poverty line or at risk of poverty and social exclusion have below 60% of the national median disposable income<sup>55</sup>, excluding Italy due to missing income data. **b.** Households living below the energy poverty line spend more than 10% of their household income on energy costs and have an income level below the national median level. HBS household sample weights applied. Supplementary Fig. 5 provides the 95% confidence intervals for the means, whereas Supplementary Fig. 6 is a cross-country comparison.

recreation services, hotels and restaurants, machinery and equipment, housing and others. Second, the differences in energy profiles are coupled with lower income levels and higher rates of poverty and energy poverty. These signal a striking inequality, exclusion and inadequacy of living conditions that is rarely attended to in environmental policy. We conclude by highlighting the need to take into account disability issues when planning the energy transition and provide recommendations to enhance environmental policies in this regard.

### Energy consumption trends of disabled and other households.

Disabled households have consistently lower income and consumption levels than other economically inactive and economically active households in the EU in 2010 (Fig. 1a,b). On average, disabled households have 76% of the income of other economically inactive households and 60% of the income of economically active households; 33% of disabled households are in the lowest income quintile, compared with 21% and 17% for other economically inactive and active households, respectively. Furthermore, only 6% of the disabled households are in the highest income quintile, compared with 28% for economically active households (Supplementary Fig. 7). The lower incomes across disabled households have clear implications for decent work, purchasing power and social equity<sup>29,30</sup>, where the inequality of disability is further exacerbated by income inequality<sup>29</sup>. The lower incomes and higher reliance on disability, retirement and other government benefits among disabled households (Supplementary Fig. 8) further highlight the lower financial resilience and ability to invest in alleviating energy poverty (for example, through energy efficiency or micro generation) among disabled people.

The lower incomes further translate into lower energy use among disabled households (a two-sided Spearman's correlation coefficient of 0.58,  $P=0$ ). The differences in energy use between household types are smaller than income, though still substantial (Supplementary Table 4). This probably reflects higher energy requirements for disabled households. On average, disabled

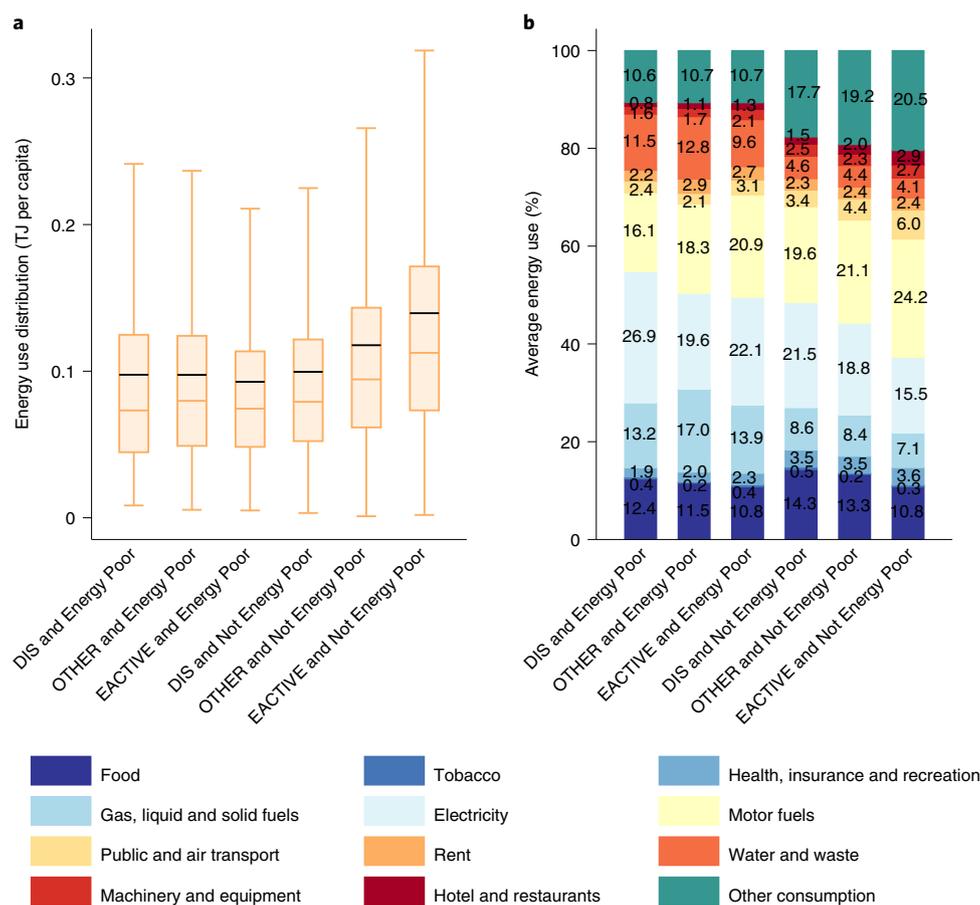
households in the EU note about 91% of the energy use of other economically inactive households and 77% of that of economically active households, at 0.10, 0.11 and 0.13 TJ per capita, respectively (Fig. 1c). This is equivalent to 28, 31 and 36 MWh per capita, respectively. The substantial energy inequality across countries (Supplementary Fig. 4) and income levels (Supplementary Fig. 2) is alarming, as energy is central to nearly every major social challenge and opportunity of our time (SDG7). The distribution of energy use is interlinked with achieving decent living<sup>31,32</sup>, alleviating poverty<sup>33,34</sup> and providing for basic needs around nourishment, health, education and shelter<sup>34</sup>. We find Belgium, Czech Republic, Slovakia, Luxembourg and Denmark to have the lowest relative energy use gap, where the energy use of disabled households still amounts to 78–88% of the energy used by economically active households. The highest difference occurs for Romania, where disabled households have energy use amounting to 47% of that of economically active households (Supplementary Fig. 4).

Disabled households have higher shares of energy associated with food, tobacco, gas and home fuels, electricity, waste and hot water services, and lower shares of energy use from health and recreation, motor fuels, public and air transport, rent, machinery and equipment, hotels and restaurants, and other consumption (Fig. 1d). This is consistent with our expectations that household consumption of disabled households will be shaped by differing access and needs.

The share of households living at risk of poverty and energy poverty (defined as households below the national median income, spending more than 10% of household income on energy costs) is also higher among disabled households at 24% and 17%, compared with 16% and 12% among other economically inactive households, and 11% and 6% among economically active households (Fig. 2). These levels are consistent—though slightly lower—compared with EU statistics estimating the risk of poverty or social exclusion at 30% among people with some or severe activity limitations in 2010<sup>35</sup>. The risk of energy poverty is lowest among disabled households in countries such as Cyprus, France and Luxembourg at 6–8%; even in these countries, however, the average risk of energy poverty is higher among disabled households than other households (Supplementary Fig. 6). These findings contribute to prior evidence suggesting that energy poverty can be several times higher than the average for certain social cohorts, for example in single parent households mostly headed by women<sup>21,36</sup>.

The average per capita energy use is similar among the disabled and energy poor, disabled and not energy poor, and other energy-poor households where both disability and energy poverty are linked to lower energy use (Fig. 3a). A comparison within disabled households suggests that disabled and not energy poor households have higher energy use associated with food, health, insurance and recreation, motor fuels, public transport, machinery and equipment, and other goods and services (Fig. 3b). Although the distribution of energy changes, the total energy amount used is very similar on average. This suggests that reducing energy poverty among disabled households (for example, through investment in energy efficiency) will not necessarily lead to increases in the overall energy use but would rather allow for more adequate satisfaction of energy needs. Among energy-poor households, home energy use (gas, electricity, solid and liquid fuels) still comprises a higher proportion of the total energy use of disabled households compared with other households, at 40% and 36%, respectively. This suggests that the effects of disability and energy poverty together exacerbate further the potential to achieve energy requirements for decent living in non-housing consumption domains.

**Other socio-demographic trends.** Income, household size, population density and age have been shown to have important implications for energy use and associated GHG emissions<sup>7,37,38</sup>.



**Fig. 3 | Energy use distribution by household type and energy poverty in the EU.** **a**, Annual energy use distribution including home energy, transport energy and energy embodied in consumption measured in terajoules per capita. The lines within the boxes represent the medians (in orange) and means (in black), whereas the boxes themselves describe the 25th (bottom hinge) and 75th (top hinge) percentiles. The top/bottom whiskers reflect the maximum/minimum if there are no outliers ( $\pm 1.5$  times the interquartile range); in cases of outliers, they describe the highest/lowest values within 1.5 times the interquartile range of the previous value. The box plots exclude all outliers. Sample sizes: DIS and Energy Poor, 2,457; OTHER and Energy Poor, 19,821; EACTIVE and Energy Poor, 7,736; DIS and Not Energy Poor, 5,265; OTHER and Not Energy Poor, 87,925; EACTIVE and Not Energy Poor, 51,762. **b**, Energy use by consumption category in percentages summing to 100% for each type of household.

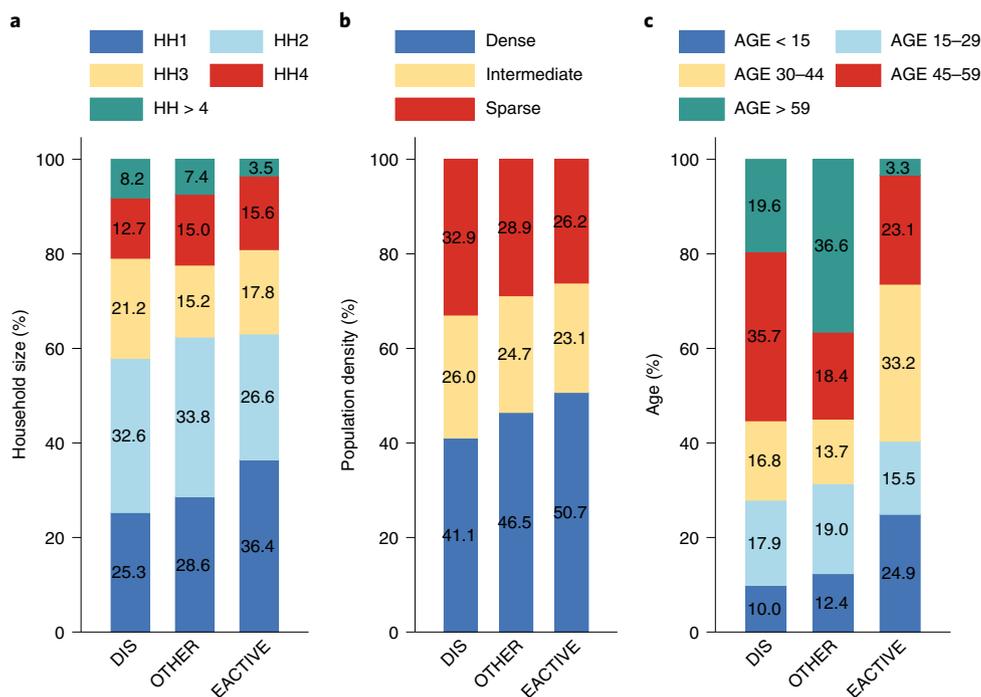
Economically inactive disabled people are less likely to live on their own with a share of one-person households of 25% compared with 36% for economically active households (Fig. 4a). This trend is particularly strong in countries of Central, Eastern and Southern Europe (Supplementary Fig. 9). At the same time, disabled households have higher shares of large households (five or more members) at 8% compared with 3.5% for economically active households. The bivariate regressions statistically confirm the positive association between disability and household sizes across most EU countries, which could be due to family support. That way, disabled households report higher potential for household sharing and so reduced energy use at home<sup>38</sup>.

Furthermore, disabled households in the EU are less likely to be located in densely populated regions with a share of 41% compared with 51% for economically active households (Fig. 4b). This difference has clear implications for sustainable transport policy, which should be designed in a way that does not overburden disabled households, residents of which may already suffer from reduced accessibility and mobility. Disabled households have a greater representation of people between 45 and 59 years (36%) and people above 59 years (20%) than other households (Fig. 4c).

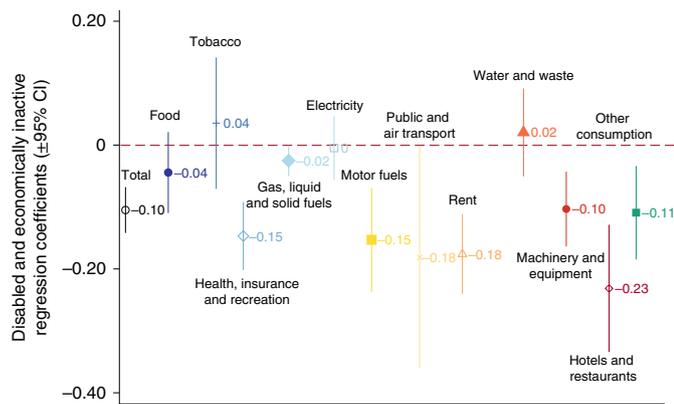
**Multivariate regressions.** Figure 5 depicts the coefficient plot on the effects of disability in the European sample. The dependent

variables change in the models: we depict the effect of disability on the total or category-specific energy use per capita in logarithmic form. Holding income, household size and other socio-demographics fixed, we find that disabled households are associated with 10% less total energy use than other households. The regression model has an adjusted  $R^2$  of 42%, based on more than 152,000 observations (Supplementary Table 5); thus, in addition to their lower incomes, disabled people experience additional effects around inclusion and opportunity to live fulfilling lives, which come with energy implications.

In addition to differences in socio-demographics such as lower income and higher household size, disabled households are associated with reduced energy use in various consumption domains. Disabled households have 15% lower energy use associated with health, insurance and recreation services. Controlling for income and other socio-demographics, disabled households use less home energy: 2% less energy use associated with gas, liquid and solid fuels, and 16% less energy associated with housing rent and real estate services. Disabled households in the EU also use much less transport energy at fixed socio-demographics, namely, 14% less energy from motor fuels and 16% less energy from public and air transport. Furthermore, disabled households report less energy use associated with machinery and equipment (10%), hotels and restaurants (21%), and other goods and services (10%). Table 1



**Fig. 4 | Socio-demographics by household type in the EU.** **a**, Household size distribution in percentages. **b**, Population density distribution in percentages, where dense reflects living in cities with at least 500 inhabitants per km<sup>2</sup>; intermediate reflects living in towns and suburbs between 100 and 499 inhabitants per km<sup>2</sup>, and sparse reflects living in rural areas with less than 100 inhabitants per km<sup>2</sup> (for more details see the Eurostat classification<sup>38,57</sup>). **c**, Age distribution of the household in percentages, depicting the average share of individual household members below 15 year olds, 15–29 year olds and so on from the total of all household members across household type. HBS household sample weights applied. Supplementary Figs. 9–11 provide an inter-country comparison.



**Fig. 5 | Multivariate regression coefficient plot of the disability effect on energy use for the total European sample.** Data are presented as regression coefficients values ±95% confidence intervals as appropriate. Multivariate regressions with a dependent variable: the log of the total energy footprint per capita by consumption category. Independent variables: disability in the household, log of net household income, household size, urbanity, age of household members and geographical region controls. As the dependent variable is in logarithmic form, the exponent of the coefficients is to be interpreted. Sample sizes: total, 152,425. Supplementary Table 5 provides the coefficient estimates, standard errors, *t*- and *P* values, total sample sizes and adjusted *R*<sup>2</sup> across consumption categories.

provides additional cross-country and socio-demographic detail for the regression model with the total per-capita energy use in logarithmic form as a dependent variable. The table shows a wide

variation in the disability effect across EU countries. In countries such as Bulgaria, Czech Republic, France, Greece, Croatia, Hungary, Ireland, Latvia and Poland, disabled households have lower total energy use, even at constant levels of income, household sizes and other socio-demographics. The lowest energy use among disabled households in these countries are noted for health, insurance and recreation services (up to 40% less energy), gas, liquid and solid fuels (up to 14%), electricity (up to 20%), motor fuel (up to 30%), housing rent (up to 26%), machinery and equipment (up to 27%), hotels and restaurants (up to 26%), and other consumption (up to 27%). The energy profiles of disabled households further point to a lower engagement in socially visible leisure consumption than other households, with systematically lower consumption of recreation, hotels and restaurants, and travel services.

It is important to note that in this section we discuss energy use differences between disabled and other households at fixed income, household size and other socio-demographics; however, as shown in Figs. 1a and 4, there are substantial differences in the socio-demographics between disabled and other households, which have additional implications for energy use. For example, Table 1 depicts a strong positive association between income and energy use across all EU countries (for past evidence on this effect, see refs. 7,8,38). In the total sample, a doubling of income produces an energy use increase of 46% (Table 1). The lower income levels among disabled households thus further contribute to their lower energy use compared with other households. Ensuring more equal opportunities of education, employment and income for disabled households directly may help equalize energy use—and so the access to essential energy services. Furthermore, the energy consumption associated with health, insurance and recreation, rent and other consumption increases most with rising income across the consumption categories in the disabled sample (Supplementary

**Table 1 | Multivariate regression estimates across countries**

Country	DIS	LNINCOME	HHSIZE	DENSE	INTERMEDIATE	AGE (0-14)	AGE (15-29)	AGE (30-44)	AGE (45-59)	N	Adjusted R <sup>2</sup>
Total sample	-0.10***	0.46***	-0.11***	-0.11***	-0.08***	0.00	0.03***	0.04***	0.05***	152,425	0.42
BE	-0.03	0.48***	0	-0.29***	-0.14***	-0.11***	-0.10***	-0.08***	-0.02*	7,162	0.40
BG	-0.08*	0.69***	-0.07***	-0.03	0.06**	0.03	0.02	0.08***	0.06***	2,982	0.42
CY	0.04	0.67***	-0.11***	0.02	0.10***	0.03	0.09***	0.09***	0.09***	2,702	0.43
CZ	-0.07*	0.41***	-0.09***	0.06***	0.04**	-0.04**	-0.06***	-0.01	0.03**	2,932	0.46
DK	-0.07	0.44***	-0.09***	-0.08***	-0.02	0.02	0.00	-0.04*	0.00	2,477	0.26
EE	-0.07	0.53***	-0.15***	0	0.20**	0.04	0.05*	0.07**	0.05*	3,632	0.25
FR	-0.12***	0.41***	-0.11***	-0.22***	-0.16***	-0.02	0.03**	0.04***	0.05***	15,732	0.31
GR	-0.14**	0.64***	-0.15***	0.01	-0.03	0.11***	0.17***	0.18***	0.13***	3,512	0.49
HR	-0.10**	0.62***	-0.07***	0.01	0.04*	0.04***	0.08***	0.09***	0.06***	3,460	0.47
HU	-0.03*	0.72***	-0.16***	0.21***	0.10***	0.08***	0.09***	0.10***	0.08***	9,936	0.45
IE	-0.25***	0.31***	-0.03	-0.19***	-0.11***	-0.09***	-0.02	0.02	0.08***	5,877	0.28
LT	-0.05	0.62***	-0.17***	0.18***	0.20*	0.10***	0.11***	0.15***	0.12***	6,103	0.34
LU	-0.10	0.25***	-0.14***	-0.51***	-0.17***	-0.05	-0.01	-0.01	0.01	3,492	0.36
LV	-0.18***	0.52***	-0.16***	0.05**	(omitted)	0.04*	0.06***	0.11***	0.08***	3,797	0.41
PL	-0.05***	0.55***	-0.11***	0.13***	0.02**	0.05***	0.04***	0.04***	0.04***	37,227	0.54
SI	0.03	0.39***	-0.24***	0.02	0.05*	0.07***	0.08***	0.06**	0.08***	3,923	0.28
SK	-0.01	0.64***	-0.08***	0.07***	0.04***	0	0	0.04***	0.04***	6,143	0.49

Dependent variable: the log of the total energy footprint per capita. Independent variables: disability in the household, log of net household income, household size, urbanity, age of household members and geographical region controls. Italy excluded due to missing income data. Two-tailed tests. We present the standard errors and *P* values in Supplementary Table 7. Significance levels: \**P* < 0.05; \*\**P* < 0.01; \*\*\**P* < 0.001.

Table 8). The income coefficient is insignificant in the context of public and air transport energy use for the disabled sample, even though it is highly significant for the total sample (Supplementary Table 5).

## Discussion

Disabled households are more likely to be experiencing energy poverty, and have lower energy use and higher energy needs than other households (Table 2). The disparities in energy use are substantial, showing a deep—and as yet rarely recognized—inequality in access to essential energy services. Past evidence also suggests that failing to satisfy energy needs may cause pain or further exacerbate the disability<sup>3,23</sup> and the observed inequality.

These insights are particularly important in the context of the substantial EU policy efforts known as the energy transition that address the transition to a low-carbon future. Energy transition policy shows an increasing recognition that vulnerable energy consumers (defined as the energy poor) must be identified and appropriately addressed by national government policy<sup>39,40</sup>. There is a recognition here that not all energy consumers have the same needs, and that different consumers have different resources available to address these needs. At present, disabled households are largely invisible in this policy effort or at the most addressed only as part of the larger energy poor category. Although energy transition policy clearly needs to pay closer attention to energy poor households, our work suggest that disabled households might need additional support and consideration even if they are not energy poor.

At the least, energy transition policy needs to take account of the needs of disabled people, who may be at risk of being further marginalized by policies that require households to reduce consumption or increase investment. Disabled people may face multiple physical, financial, organizational and social barriers to participation in pro-environmental activities<sup>13</sup>, which tend to go unrecognized in policy appeals towards active, choice-making individuals<sup>4</sup>.

We hope that this paper offers a useful step in recognizing disabled people as an important demographic for EU energy policy, and in documenting the disparities in energy use between disabled households and others. Given these disparities, there is also a need to assess the impacts of energy and climate policies on this substantial demographic, and in doing so to understand the distributive consequences of policy. This requires political commitment to monitoring impacts of policy on disabled people, as well as promoting the inclusion of disabled people in policy-making. Increasing the representation of disabled people<sup>13</sup> in the design and implementation of environmental and energy policies will probably help avoid regressive impacts and better capture their potentially higher energy (and thus emission) requirements. A wider recognition of disabled people in environmental citizenship debates is also key to highlight their agency and enable a contribution and fulfilment of responsibility that disabled people can and wish to make<sup>13</sup>.

The specific challenges that disabled households are likely to face according to our findings above, are associated with these households' lower incomes, and higher consumption of particular energy services. These include a sensitivity to increases in living costs, particularly to costs of home heat and electricity, given that they consume proportionately more of these. Disabled households are also less likely to have capital to invest in the changes associated with the energy transition. Note that these characteristics paint a picture of the average experience of a disabled household in the EU, there will of course be considerable variation between nations and between households. This represents an opportunity for research: to investigate the range of experiences of disabled households in the EU and to identify national or regional contexts in which the conditions are conducive to a more positive energy consumption experience. For example, countries such as Denmark, Slovakia, Belgium, Czech Republic and Luxembourg show lower energy inequality across household types in our analysis, and in general report lower risks regarding poverty, in-work poverty and social protection<sup>26</sup>.

**Table 2 | Summary of energy trends associated with disability**

	Energy use	Energy needs
Transport	Motor fuels (-)	Access to private vehicle (+) <sup>4</sup>
	Public and air transport (-) Past evidence suggesting lower car, air, active and public transport associated with poor health status <sup>22</sup> .	
Home energy	No significant differences in the regression analysis, but higher gas and electricity shares than other households (+)	Heating and cooling requirements (+), for example, higher indoor temperatures, longer periods of warmth and air conditioners use <sup>3,23</sup>
	Past evidence suggesting higher electricity use associated with poor health status <sup>22</sup> .	
		Home appliance use (+), for example, additional washing and drying facilities <sup>3</sup> , higher costs associated with pre-payment meters <sup>23</sup>
Food	No significant differences in the regression analysis, but higher food shares than other households (+)	Greater risk of malnourishment <sup>18</sup>
Health and recreation	Medical products, appliances and equipment (+)	Vital health care and medical/recreational equipment and services (+) Higher health care expenditure <sup>13</sup>
	Out-patient and hospital services (+)	
	Packaged holidays (-)	
	Recreational and cultural activities (-)	
	Personal care (-)	
	Insurance (-)	
Other consumption	Communication (-)	Other supporting equipment and services (+)
	Hotels and restaurants (-)	
	Education (-)	

The table reflects the literature, our multivariate regression analysis depicting the disability effect on energy use (Fig. 5) and expenditure (Supplementary Table 6).

With many nations aspiring towards a transition from gas to electric heating, and to dramatically increase the energy efficiency of the housing stock, the consideration of disabled households' needs in these policies will be critical. Different nations will put different amounts of the cost burden of this transition on the consumer according to what is politically acceptable, which is likely to have more substantial negative effects for disabled households<sup>41</sup>. Changes to travel costs and infrastructure will also affect disabled people, despite their relatively low consumption of these services at present. Given the constraints on energy use in disabled households that are visible in our data, the energy transition clearly risks further restricting access to energy- and carbon-intensive necessities for disabled people.

There may also be opportunities to address disability and energy policy in conjunction. For instance, given that disabled households have relatively consistent home energy (gas and electric) use across energy poor and non-energy poor households, this suggests that disabled households would be a good candidate for investment in household energy efficiency. This would need substantial financial support (no cost to household measures) given that most disabled people are on low incomes. It would also likely have more substantial health benefits (on average) than energy efficiency measures for non-disabled households. Improvements in social provisioning are also key to reduce income inequality and enhance social support and, in turn, life satisfaction<sup>30</sup>. Calls for universal adult social care for all in need emphasize that high-quality care is essential to maintain health, autonomy and capacity for social participation, which can simultaneously improve social wellbeing, enrich local communities by enabling a wider participation and prevent or delay adverse health effects<sup>42</sup>.

Our findings, and the invisibility of disabled households in the energy transition, suggest the need for a closer relationship between disability and energy policy. Disabled people are very disadvantaged in terms of energy and other social indicators in our data. Clearly,

there is room for more radical approaches to level up the gap between disabled and non-disabled households.

## Methods

**EU household budget surveys and disability definition.** Across the EU, 19 countries collected data on permanent disability of household members as a reason for not working in their HBSs, including Belgium (BE), Bulgaria (BG), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Greece (GR), France (FR), Croatia (HR), Hungary (HU), Ireland (IE), Italy (IT), Lithuania (LT), Luxembourg (LU), Latvia (LV), Poland (PL), Romania (RO), Slovenia (SI), Slovakia (SK). Italy provided data on consumption expenditure and disability as a current activity status, but no income data. The National Statistical Institutes in each member state carry out the HBSs with the main focus on consumption expenditure, where each country has considerable freedom to decide on the methodology and resource allocation for the respective survey<sup>43</sup>. Eurostat then harmonized and disseminated HBSs for a total of 174,966 households among these 19 countries. The surveys reflect trends in 2010, which is the latest available Eurostat wave at the time of writing this article.

The HBSs do not collect information on disability of household members directly. They instead collect data on the current activity status of household members, including a permanently disabled option for economically inactive individuals<sup>44</sup>, where individuals can be classified as permanently disabled or unable to work due to a physical or other disability. This definition excludes disabled people who are economically active (for example, working or unemployed) or economically inactive while fitting any other activity status (for example, children, the retired or those in full-time education). Although we are certainly very interested in understanding their energy use patterns, in the current analysis we do not have the data to single out the energy patterns of disabled people that are economically active or economically inactive under another activity status. The subset of persons who are economically inactive due to disability on which we focus on here is thus not representative of the population of disabled persons (see Supplementary Table 1 for other statistics on disability). Supplementary Table 2 contains the sample distribution by household type.

Other surveys show that the EU employment rate among disabled people amounts to 47–51% (compared with 67–75% among the non-disabled)<sup>36,45</sup>, that is, about half of disabled people are unemployed or inactive. Although we cannot generalize our findings to all disabled people or capture in-work poverty, the

subset of economically inactive disabled households is likely to be among the most disadvantaged and excluded. Economically inactive disabled people of working age are more likely to need assistance and face higher risks associated with more severe levels of impairment and barriers to social integration than employed disabled people<sup>26,46,47</sup>. Economically inactive disabled people are also more likely to suffer from poverty and material deprivation (including inability to pay energy and other household bills), particularly in countries with lower social transfers<sup>27,28</sup>. Furthermore, austerity measures enacted by governments after the financial crisis of 2008 and more recently the COVID-19 pandemic disproportionately impacted the lives of disabled people and targeted cuts in disability-related benefits for working age people<sup>28,48</sup>. Consequently, there is a rationale for focusing our analysis on a subset of economically inactive disabled people who are of working age and outside the labour market primarily due to disability.

In our analysis, we compare disabled households with (1) other economically inactive households, which includes households where at least one person of legal working age is economically inactive due to retirement, training or unpaid work experience, fulfilment of domestic tasks, military or community service<sup>44</sup>; and (2) economically active households, where none of the household members of legal working age is economically inactive, including working individuals and the unemployed seeking work<sup>44</sup>.

**Energy use calculations.** We used the multiregional input–output database EXIOBASE v.3.7 for 2010 energy footprint analysis. We applied a net energy indicator measuring annual energy use in terajoules at the product level (200 products). Net energy is suitable for footprint analysis as there is no double counting associated with the conversion from primary sources (derived directly from nature, for example, coal) into secondary sources (transformed for a certain industry or household use, for example, electricity)<sup>49</sup>. For the purpose of this article, we use energy footprint and energy use interchangeably.

Net energy accounts depict the energy use of households and industry (to produce products for household consumption) as well as losses associated with conversion and distribution processes. In terms of final consumption categories, our net energy accounts include both home energy and energy embodied in the consumption of goods and services delivered through the global supply chains. That way, our analysis goes beyond traditional accounts of home energy (for example, electricity use and heating requirements) and encompasses further energy uses, which are key to the provision of wellbeing (for example, food, mobility, health services, equipment, education). For the purpose of our analysis, we communicate the total net energy, which combines transport energy, non-transport (industry use and other) energy, non-energy use and losses, and energy industry's own use. Non-energy use covers fuel use as raw materials in the different sectors and are not consumed as fuel or transformed into another fuel<sup>50</sup> such as petroleum products and coal. Energy data were aligned with the residential principle and consolidated with the International Energy Agency energy flow and classifications to enable allocation to EXIOBASE industries, final consumption and products<sup>51,52</sup>. Modelling uncertainties arise from a lack of energy and extraction detail, allocation of household direct energy use, hidden or confidential data and the conflict between the residence versus territorial principle<sup>53</sup>.

We harmonized the consumption data from the HBS and energy extensions from EXIOBASE to calculate energy use for our household level sample. Supplementary Fig. 1 details the calculation procedure and the harmonization of sources.

**Additional social indicators.** Energy-poor households are unable to afford the level of energy services needed for a decent life<sup>34</sup>. Here we categorize households as living in energy poverty when they spend more than 10% of their household income (or total consumption spending for Italy and Luxembourg) on energy costs at an income level below the national median level<sup>9</sup>. This amounts to an adapted 10% measure, counting households as energy poor when they spend 10% or more on energy costs and they have an income level below the national median level. In measuring energy poverty this way, we combine the UK's old and new energy poverty definitions<sup>34</sup>. To be specific: there are two differences between our indicator here, and the original 10% measure proposed by Brenda Boardman. (1) We only include households that earn below the national median level (thereby excluding wealthier households who are overconsuming); (2) we use real rather than modelled energy costs (this means that we are likely to lose some of the underconsumers who are self-disconnecting; so called hidden energy poor). This is the best available indicator in the data set we are working with here, although we recognize that it does not necessarily reflect the full picture of Energy Poverty (among disabled people) in each nation.

The population living in energy poverty and poverty is largely overlapping as they share common drivers such as low incomes, high fuel bills and ill health<sup>54</sup>. Here we measure risk of poverty and social exclusion through the Eurostat's threshold set at 60% of the national median disposable income<sup>55</sup>.

**The statistical model.** We present income, consumption, energy use and poverty bar charts, graphing the mean and the 95% confidence interval for each household type using error bars<sup>56</sup>. Similar to a past energy analysis<sup>38</sup>, we perform a multivariate regression analysis for the total sample and for each country *c* separately; yet, this time we include disability as an independent variable in the regression model, which has not been done to our knowledge. The unit of analysis

is the household *i*, where we estimate household energy use based on household consumption data by-product and country-level carbon intensities by-product, where beta is the regression coefficient varying by variable and country.

$$\begin{aligned} \text{LNE}_{ci} = & \beta_{c0} + \beta_{c1} (\text{DISABLED}_{ci}) \\ & + \beta_{c2} (\text{LNINCOME}_{ci}) + \beta_{c3} (\text{HHSIZE}_{ci}) \\ & + \beta_{c4} (\text{DENSE}_{ci}) + \beta_{c5} (\text{INTERMEDIATE}_{ci}) \\ & + \beta_{c6} (\text{AGE}_{ci}) + \beta_{c7} (\text{REGION}_{ci}) \end{aligned}$$

LNE stands for the estimated energy use measured in terajoules per capita, in logarithmic form, total or across consumption categories. DISABLED captures households with disabled and economically inactive persons (dummy variable). LNINCOME measures the effect of net disposable income per capita, in logarithmic form, which can be interpreted as the income elasticity of total energy use. HHSIZE measures the number of household members, sharing accommodation and expenses. The population density dummies DENSE and INTERMEDIATE divide the sample on households living in cities with at least 500 inhabitants per km<sup>2</sup>, households living in towns and suburbs with a density between 100 and 499 inhabitants per km<sup>2</sup>, and sparsely populated areas with less than 100 inhabitants per km<sup>2</sup> (see past documentation on the classification for more details<sup>58,57</sup>). The AGE variables measure the role of age distribution for consumption and energy use, particularly depicting the number of household members within the following age categories: below 14 years old; between 15 and 29 years old; between 30 and 44 years old; and between 45 and 59 years old (with above 59 years olds as a base variable). The model further includes a set of geographical REGION variables accounting for regional differences such as technological, geographical and socio-economic context, which may influence energy use (categorical variable). The regional variable uses NUTS 2010 two-digit level unless otherwise specified (Supplementary Table 3). We add another model specification including other economic inactivity as a variable, which does not significantly affect the effect of disabled and economically inactive (Supplementary Fig. 12); in essence, we still find a significant difference between disabled and other economically inactive households holding income, household size, density, region and age distribution constant.

**Limitations.** Although the EU's HBSs are largely harmonized<sup>43</sup>, substantial differences occur in terms of detail that surveys collect and disseminate. More harmonized and nuanced definitions of disability and further details on what kind of impairment or disability people will allow for a more representative assessments of energy consumption and needs among disabled people and more nuanced interventions depending on the type of disability.

In the modelling of energy use, our analysis captures household consumption and the energy embodied in household purchases. We therefore cannot capture differences across household types and countries in terms of consumption of community and government services (and their associated impacts) that do not result in household expenditure outflow. Furthermore, more detail on the physical, socio-economic and political context in which energy use takes place will be beneficial to elaborate on the circumstances in which energy demands associated with disability increase or decrease. We also could not account for price differences between disabled and non-disabled households in our analysis; for example, in England, a greater proportion of disabled households are on pre-payment meters compared with other households, associated with challenges such as increased costs, the risk of self-disconnection and the need to top up<sup>21</sup>. If disabled households systematically pay higher prices, we will be overestimating their energy use compared with non-disabled households.

Although our model lacks a temporal dimension, we expect that the observed trends between disability and energy use are dynamic in several ways. On a micro level, the dynamics around the course of the disability may be key, where associated energy use is not necessarily static and may change, for example, with high quality care<sup>18</sup>. On a macro level, factors around energy prices changing with the energy transition, increased climate impacts and frequency of extreme events and changes in the broader political, infrastructural and provisioning context may all have key energy implications and so influence the living situation for disabled people.

**Reporting Summary.** Further information on research design is available in the Nature Research Reporting Summary linked to this article.

## Data availability

The energy use data behind the analysis is openly available through the Research Data Leeds Repository hosted by the University of Leeds at <https://archive.researchdata.leeds.ac.uk/891/> (ref. 58). The dataset contains energy footprints (total and by consumption category) and categorical variables on poverty, energy poverty and disability, all of which are generated by the authors. It also contains household IDs, country codes and household weights generated by Eurostat and corresponding to the HBSs. The household and country ID variables are included to allow for households to be identifiable by users of the HBS dataset disseminated by Eurostat. Other variables in the HBSs (for example, household

size, income, population density and so on), which have been used in the statistical analysis, are subject to controlled access through the official Eurostat portal. Access to the HBS microdata is granted for scientific purposes only through applying to have your research organization recognized as a research entity and submitting a research proposal requesting the specific data. Once the research entity is recognized (mailbox for requests to be recognized as a research entity: ESTAT-ENTITIES-ASSESSMENT@ec.europa.eu), the research proposal is submitted via an online form via Microsoft Access Workflow Tool (accessible via an EU-login). The national statistical authorities are consulted before approving research proposals, where the standard consultation period is four weeks. Access is usually granted to partially anonymised data for a period of time following the guidelines for publication. More information about the procedure can be found at [https://ec.europa.eu/eurostat/documents/203647/771732/How\\_to\\_apply\\_for\\_microdata\\_access.pdf/82d98876-75e5-49f3-950a-d56cec15b896](https://ec.europa.eu/eurostat/documents/203647/771732/How_to_apply_for_microdata_access.pdf/82d98876-75e5-49f3-950a-d56cec15b896). The EXIOBASE database is available at <https://zenodo.org/record/4277368>.

### Code availability

The codes (to estimate energy use based on household expenditure (MATLAB), and to perform the statistical analysis (Stata) and concordances used to derive final energy use, are openly available through the Research Data Leeds Repository hosted by the University of Leeds at <https://archive.researchdata.leeds.ac.uk/891/>. The energy use data behind the analysis is openly available through the Research Data Leeds Repository hosted by the University of Leeds at <https://archive.researchdata.leeds.ac.uk/891/> (ref. <sup>58</sup>).

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## Author contributions

D.I. and L.M. jointly designed the study, designed the analysis and wrote the paper. D.I. conducted the analysis.

## Competing interests

The authors declare no competing interests.

## Additional information

**Supplementary information** The online version contains supplementary material available at <https://doi.org/10.1038/s41560-021-00932-4>.

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### Software and code

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Data collection Raw data was received from Eurostat in Excel files for each country. It was then imported in Stata IC 14 and merged into a single dataset.

Data analysis MatLab R2018 (energy use analysis), Stata IC14 (statistical analysis)

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#### Data availability

The energy use data behind the analysis is openly available through the Research Data Leeds Repository hosted by the University of Leeds: <https://archive.researchdata.leeds.ac.uk/891/>

Ivanova, Diana and Middlemiss, Lucie (2021) Dataset associated with "Characterising the energy use of disabled people in the European Union towards inclusion in the energy transition". University of Leeds. [Dataset] <https://doi.org/10.5518/1048>

The dataset contains energy footprints (total and by consumption category) and categorical variables on poverty, energy poverty and disability, all of which generated by the authors. The dataset also contains household IDs, country codes and household weights generated by Eurostat and corresponding to the HBSS. The household and country ID variables are included in order to allow for households to be identifiable by users of the HBS dataset disseminated by Eurostat.

Other variables in the HBSs (e.g. household size, income, population density etc.) which have been used in the statistical analysis are subject to controlled access through the official Eurostat portal. Access to the HBS microdata is granted for scientific purposes only through applying to have your research organisation recognised as a research entity and submitting a research proposal requesting the specific data. Once the research entity is recognised (Mailbox for requests to be recognised as a research entity: [ESTAT-ENTITIES-ASSESSMENT@ec.europa.eu](mailto:ESTAT-ENTITIES-ASSESSMENT@ec.europa.eu)), the research proposal is submitted via an online form via Microsoft Access Workflow Tool (accessible with EU-login). The national statistical authorities are consulted before approving research proposals, where the standard consultation period is 4 weeks. Access is usually granted to partially anonymised data for a period of time following the guidelines for publication. More information about the procedure can be found following the link:

[https://ec.europa.eu/eurostat/documents/203647/771732/How\\_to\\_apply\\_for\\_microdata\\_access.pdf/82d98876-75e5-49f3-950a-d56cec15b896](https://ec.europa.eu/eurostat/documents/203647/771732/How_to_apply_for_microdata_access.pdf/82d98876-75e5-49f3-950a-d56cec15b896)

The EXIOBASE database is available on Zenodo: <https://zenodo.org/record/4277368>

Code availability

The codes (to estimate energy use based on household expenditure (MatLab), and one to perform the statistical analysis (Stata) and concordances used to derive final energy use are openly available through the Research Data Leeds Repository hosted by the University of Leeds: [https://archive.researchdata.leeds.ac.uk/891/Ivanova, Diana and Middlemiss, Lucie \(2021\) Dataset associated with "Characterising the energy use of disabled people in the European Union towards inclusion in the energy transition". University of Leeds. \[Dataset\] https://doi.org/10.5518/1048](https://archive.researchdata.leeds.ac.uk/891/Ivanova,DianaandMiddlemiss,Lucie(2021)Datasetassociatedwith%20CharacterisingtheenergyuseofdisabledpeopleintheEuropeanUnion%20towardsinclusionintheenergytransition)

## Field-specific reporting

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Life sciences  Behavioural & social sciences  Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see [nature.com/documents/nr-reporting-summary-flat.pdf](https://nature.com/documents/nr-reporting-summary-flat.pdf)

## Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

### Study description

Quantitative data study exploring the energy use associated with consumption and associated socio-demographic characteristics. The study analyses data on economic activity and particularly economic inactivity associated with permanent disability - and describes and compares energy profiles of disabled people with other types of households (e.g. economically active and other economically inactive). The study combines microdata on expenditure with energy intensities based on the multiregional input-output database EXIOBASE to provide an overview of the energy distribution among European households.

### Research sample

We perform the analysis based on the country representative Household Budget Surveys (HBS) collected and performed by EU member states and harmonized by Eurostat. Our sample includes 19 EU countries and a total of 174,966 households who provided expenditure and economic activity data, including households from Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Greece, France, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Poland, Romania, Slovenia, Slovakia.

We chose this study sample as it offers data on cross-country energy use with a comprehensive consumption detail and some indications on economic activity and disability. HBS are among the most comprehensive household surveys conducted by the national statistical offices of the EU Member States. Each HBS is a sample survey of thousands of households that are asked to keep records of their expenditures on different kinds of consumer goods and services over a specified period of time, usually two weeks. The HBS also includes household interviews, collecting basic information on the households, income and regular expenditure. The main focus in this survey is Consumption Expenditure, which captures individual or collective spending on goods or services.

The full quality report and data description of the EU Household Budget Surveys can be found here: [https://ec.europa.eu/eurostat/documents/54431/1966394/LC142-15EN\\_HBS\\_2010\\_Quality\\_Report\\_ver2+July+2015.pdf/fc3c8aca-c456-49ed-85e4-757d4342015f](https://ec.europa.eu/eurostat/documents/54431/1966394/LC142-15EN_HBS_2010_Quality_Report_ver2+July+2015.pdf/fc3c8aca-c456-49ed-85e4-757d4342015f)  
<https://ec.europa.eu/eurostat/documents/203647/7610424/HBS+User+Manual/fb5d8371-08fe-4ecf-bca6-b40984fde0b6>

A total of 7,722 households (equivalent to 4.4% of the total sample) report economic inactivity due to permanent disability. In the article we communicate the country samples across disabled and other households. Household characteristics by activity and employment, number of active persons, type of household, age of the reference person, degree of urbanisation and main source of income is provided by Eurostat: <https://ec.europa.eu/eurostat/web/household-budget-surveys/database>

### Sampling strategy

We did not carry out the sampling ourselves, but used secondary data made available through national statistical offices and the Eurostat. The following is derived from the quality report of the HBS. The HBS in most countries are based on probability sampling by design, although there are some exceptions. Most of the participating countries drew a sample of households in a way that the probability of a household being selected is known (technically known as a probability design). In this way, the results can be reliably projected from the sample to the household reference population with known levels of precision, i.e. standard errors and confidence intervals for survey estimates can be constructed. On the other hand, non-probability schemes (e.g. Quota selection) were implemented in the Czech Republic. Many of the samples were stratified by geographical dimensions, which improves the representability of the samples by ensuring a minimum adequate size by region. The HBS data are weighted, where sample weights correct for imperfections in the sample and non-response that may lead to bias. The HBS were also "calibrated" to external data sources on known population characteristics (e.g. population totals by age, NUTS2 region etc). The HBS quality report presents a detailed overview of sampling and non-sampling errors.

The achieved sample sizes were compared to effective sample sizes for each country, where the design effect (reported in the 2010 Quality report) indicates how much the actual sample size has effectively been increased or reduced as a result of implementing a

	sample design which is different from the basic simple random sample design for each country. Most countries (except for Sweden and Czech Republic) achieved sample sizes above the effective sample sizes.
Data collection	<p>The common feature of all of the HBS is that households are asked to maintain detailed diaries of expenditure over a fixed time period (two weeks in most countries). In order to reduce the burden on households when completing the detailed expenditure diaries, households have been increasingly encouraged to attach cash register receipts that contain the details of the purchases of their diaries instead of directly recording such information. Some countries used monetary incentives to get people to co-operate. The HBS also include household interviews generally conducted before and after the period of diary recording. The interviewer plays a key role to motivate households to complete their diaries. National Statistics Offices demand experienced staff to take part as interviewers and organize training sessions prior to the survey launch in order to familiarize interviewers with the survey components. Computer-assisted telephone interviewing is also used by some countries in order to keep processing errors to the minimum, where the computer checks regarding question responses, problems with the survey, inadmissible and inconsistent responses. More country-specific information on the collection of substantive information is made available in the EU quality report.</p> <p>The main focus of the HBS is consumption expenditure used to derive consumer price indices. Therefore, one can assume that the data collectors were blinded to the hypothesis in our study.</p>
Timing	The latest HBS data wave made available at the moment is the 2010 wave. Most HBS are conducted annually, allowing the statistical offices to revise and update their expenditure weights each year. Some countries conduct HBS less frequently (see the EU quality report for country specific information). Some HBS are conducted throughout the calendar year, so seasonal changes are taken into account.
Data exclusions	No data were excluded from the energy use analysis. The samples of Italy and Luxembourg were excluded from the statistical analysis, as they did not provide reliable data on income levels.
Non-participation	The mean response rate at EU level lies around 60%. There are however important variations between the countries: from 5.6% in Belgium to 87.6% in Romania. The low figure for Belgium is explained by the fact that it is calculated taking into account the total population of households initially contacted to participate in the HBS, not the number of households that agree to participate and drop out later. Most surveys adjusted their household weights to reduce non-response bias. Some countries allowed for a substitution of non-responding households, which made their samples bigger and potentially increased the level of accuracy. Such substitution was strictly controlled, where non-response households were substituted with households with similar characteristics regarding household size, region, type of ownership, economic activity status etc.
Randomization	Countries applied random sampling design for the HBS, e.g. particularly applying a two-stage sample selection. A sample of geographical areas was selected first with a probability proportional to the size; in a second stage, the simple random selection of household occurred within each sample area.

## Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

### Materials & experimental systems

n/a	Included in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> Antibodies
<input checked="" type="checkbox"/>	<input type="checkbox"/> Eukaryotic cell lines
<input checked="" type="checkbox"/>	<input type="checkbox"/> Palaeontology and archaeology
<input checked="" type="checkbox"/>	<input type="checkbox"/> Animals and other organisms
<input type="checkbox"/>	<input checked="" type="checkbox"/> Human research participants
<input checked="" type="checkbox"/>	<input type="checkbox"/> Clinical data
<input checked="" type="checkbox"/>	<input type="checkbox"/> Dual use research of concern

### Methods

n/a	Included in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> ChIP-seq
<input checked="" type="checkbox"/>	<input type="checkbox"/> Flow cytometry
<input checked="" type="checkbox"/>	<input type="checkbox"/> MRI-based neuroimaging

## Human research participants

Policy information about [studies involving human research participants](#)

Population characteristics	See above.
Recruitment	n/a We did not recruit research participants, but used secondary data instead.
Ethics oversight	We complied with the data storage and confidentiality terms of Eurostat. Since we were working with secondary data already in the public domain, we did not need to submit our work to ethical review.

Note that full information on the approval of the study protocol must also be provided in the manuscript.