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Review

The Intersection of Fuel and Transport Policy in Scotland: A Review of Policy, Definitions and Metrics

Keran Sarah Boyd [1], Christian Calvillo [2,*], Tanja Mueller [3], Xiaoyi Mu [1] and Tong Zhu [1]

[1] Centre for Energy, Petroleum and Mineral Law & Policy, University of Dundee, Dundee DD1 9SY, UK; 2397800@dundee.ac.uk (K.S.B.); x.mu@dundee.ac.uk (X.M.); tzhu001@dundee.ac.uk (T.Z.)
[2] Centre for Energy Policy, University of Strathclyde, Glasgow G1 1XQ, UK
[3] Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow G4 0RE, UK; tanja.muller@strath.ac.uk
* Correspondence: christian.calvillo@strath.ac.uk

Abstract: This paper is a literature review of fuel and transport poverty in the U.K. with a focus on contextualising this challenge in Scotland. Building on the discussion in the literature, we see that the objective of policy interventions should be to provide a mechanism for identifying vulnerable households. First, we analyse the definitions of fuel, energy, and transport poverty and observe that definitions in policy have been used to limit the scope of the issue to make it more easily addressable. In contrast, academic research points out that fuel poverty should not only encompass all energy use, including household heating, but that transport poverty should be considered under the same umbrella as the drivers overlap. We then consider the indicators used to measure fuel and transport poverty, finding that the thresholds set are arbitrary and only measure one of many possible drivers, namely expenditure. Through an analysis of the drivers, it is clear that both fuel and transport poverty are complex multidimensional challenges requiring a combination of indicators to allow the policy to accurately identify vulnerable households.

Keywords: fuel poverty; transport poverty; just transition; energy policy

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1. Introduction

In Northern European countries with biting winters, fuel poverty is high on the political agenda. Fuel poverty, in broad terms, refers to not being able to afford energy bills, having to under-heat homes and/or reduce consumption otherwise.

Taking Scotland as an example, the fuel poverty statistics are revealing. Energy Action Scotland, a national advocacy organisation campaigning to end fuel poverty in Scotland, reported in 2019 that almost one in four (24.9%) of households were in fuel poverty, with over one in eight households (12.4%) in extreme fuel poverty [1]. In response to this ongoing challenge, in 2019, the Scottish Parliament passed the Fuel Poverty Act [2]. The legislation sets forth an official definition, target, and strategy for addressing fuel poverty at a national level.

Transport poverty, on the other hand, is a less well-defined concept, with many different approaches used to characterise it [3]. It is also a prevalent challenge in Scotland, where one in five are at high risk of transport poverty, i.e., not being able to afford transport costs, limiting access to work, education, and/or other services [4]. The Scottish Government note that the transition away from coal for heat since the 1960s has decimated communities through a lack of planning and that the current energy transition cannot follow the same path. The cost and consequences of the energy transition need to factor in conditions of vulnerability which may expose certain households to fuel poverty.

Fuel poverty is noted as a key element in a just transition, which should aim to reduce overall poverty [5]. Addressing the issue of energy poverty and the vulnerability of households to this condition is a prerequisite for the just transition [6]. As energy systems

are reimagined around the transition to low-carbon fuel, there is an opportunity to address vulnerability via new policy mechanisms. Sovacool and Dworkin [7] define the concept of energy justice as "a global energy system that fairly disseminates both the benefits and costs of energy services", which emphasises the need to implement policies which decarbonise society whilst improving socioeconomic and spatial inequalities rather than worsening these conditions.

National Energy Action estimates that over seven and a half million households in the U.K. will be in fuel poverty by April 2023, owing to steep increases in the average annual household energy bill from GBP 1138 in 2021 to GBP 2500 in 2023. The current cost of energy per household is expected to rise from mid-2023 with the ending of the Energy Price Guarantee (EPG), a government intervention which maintains the average cost per household artificially through subsidy. With inflation at record highs, the cost-of-living crisis will continue to drive higher levels of fuel poverty [8].

As we will see throughout this paper, recent literature has considered transport and fuel poverty as manifestations of the same underlying conditions, and we will discuss the value of addressing this so-called 'double energy vulnerability'. The overlap in causation between transport and energy poverty indicates that these conditions could be evaluated together.

Policy makers recognise the importance of tackling fuel and transport poverty as part of a just transition and include transport in the recent Draft Energy Strategy and Just Transition Plan [9]. Although the Scottish policies are progressive in a broader context, there are significant oversights in the fuel and transport poverty definitions and thresholds, which ignore the socio-spatial, multidimensional aspects inherent to this societal challenge.

Fuel and transport poverty are complex issues that have significant health, financial, and social implications [10]. Investigating fuel and transport poverty issues are particularly crucial amid living cost crises when these negative implications are likely to be amplified. This present study attempts to contribute to understanding the extent of the problem and developing effective strategies to address it.

This review seeks to understand the landscape of energy and transport poverty in Scotland to describe the country's position in this regard. To this end, we assess foundational concepts of fuel poverty, the intersection with transport poverty, and the possibility of a unified definition.

This review reveals that there is an underlying issue with the approach taken to measure fuel and transport poverty in that expenditure-based indicators with thresholds are arbitrary for the purposes of identifying vulnerable households, and risk-based assessments of vulnerability are more appropriate to identify the underlying drivers of fuel and transport poverty as they account for the multidimensional nature of both conditions. Furthermore, it is found that the drivers of transport and fuel poverty overlap, known as 'double energy vulnerability' (Double energy vulnerability usually refers to the increased likelihood of negative impacts on wellbeing due to the intersection of fuel and transport poverty. See Robinson and Mattioli [11] for a detailed discussion). However, there is more to be done to monitor and measure these drivers to prove a correlation.

2. Energy and Fuel Poverty: Foundational Concepts

Energy, fuel poverty, and domestic fuel poverty are often used interchangeably in the literature, generally relating to access to or difficulty consuming energy services regardless of the cause [12]. The definition can be fluid depending on the context to which it refers. Although the academic debate on the differences and similarities of these concepts is beyond the scope of this paper, there are examples in the literature exploring this debate (see, for example [13,14]).

Fuel poverty as a concept was introduced by Isherwood and Hancock in 1979. Fuel poverty was used to describe the increasing expense of fuel on income-stressed families and defined as "households with high fuel expenditure as those spending more than twice the median on fuel, light and power" [15].

Although fuel and energy poverty have been used interchangeably to describe the conditions in the industrialised world, it should be noted that energy poverty is also used in relation to energy access in the developing world, aligning with the Millenium Development Goals and Sustainable Development Goals. Energy poverty in the context of international development policy relates to universal energy access as being foundational for human development [16]. Although energy poverty as a field encompasses this perspective of the developing world, this research does not focus on energy poverty as it refers to the complete or partial lack of access to electricity and other energy sources. For reading on energy poverty in developing countries, a 2022 meta-analysis by Sy and Mokkadem provides a comprehensive overview of the academic volume.

This review is concerned with what has typically been defined as fuel poverty or domestic fuel poverty, which, in contrast to energy poverty, has tended towards use for industrialised countries where households lack the disposable income required to pay for their energy needs [17]. Recognised as a distinct form of deprivation and disadvantage, fuel poverty lies at the intersection of low incomes, domestic energy inefficiency, and high energy prices [18,19].

An early definition of fuel poverty was developed in 1991 by Brenda Boardman and introduced two key concepts into the literature, namely the limitation of fuel poverty to heating and the ten percent rule (TPR). This widely relied-on definition sets a poverty threshold for household spending on heat as a portion of total income. This definition of fuel poverty was adopted by the U.K. government in 1997 and was relied on extensively by the Scottish government in the formulation of a legislated definition of fuel poverty.

The definition used in the Scottish Fuel Poverty Act [2] is as follows:

> "A household is in fuel poverty if the household's fuel costs (necessary to meet the requisite temperature and amount of hours as well as other reasonable fuel needs) are more than 10% of the household's adjusted net income and after deducting these fuel costs, benefits received for a care need or disability, childcare costs, the household's remaining income is not enough to maintain an acceptable standard of living."

Fuel poverty in the UK has featured on the political agenda since the 1990s as energy price increases have exceeded the increase in household income, combined with having buildings that are 'hard-to-treat' [20]. 'Hard-to-treat' is a challenge which describes the physical state of buildings and other dwellings as relating to their ability to be adapted for energy efficiency purposes, for example, being difficult or expensive to retroactively insulate.

The limitation of the scope to household heating diverges from a subset of the literature, with some empirical studies in the European Union including all energy use, including lighting, cooking, cooling, and appliance use, as within the measured scope [21–24]. In addition, the European Commission accepted a unified definition of energy poverty in October 2020, which includes all forms of energy use its definition [12].

Limiting the definition to only include heat is somewhat arbitrary as it neglects the impact of energy use for applications other than heating. As we will discuss, when considering the rationale for unified consideration of transport and fuel poverty, there is a give and take in household expenditure when it comes to total energy use and, therefore, makes sense to consider all energy use rather than heating versus transport versus general household energy expenditure. Some consideration needs to also be given to feasibility, and the limitation to heating only is an attempt to narrow the extensive scope of the challenge to something addressable within a single piece of legislation [19]. A common complaint across the literature is the lack of a unified definition of, or a clear distinction between, fuel and energy poverty [12,16,25]. This review makes use of both terms: energy and fuel poverty. Fuel poverty is used to refer to what is covered by the Scottish Act, i.e., heating related, whilst energy poverty, where appropriate, will be used to describe the broader challenges which may also encompass transport poverty. Though this research recognises the conceptual differences between energy and fuel poverty, the academic debate is beyond the scope of this paper.

In comparison, in the United States of America, there is no federal recognition of energy poverty as a distinct issue [26]. Although there are federally funded programs to assist low-income households which serve as de facto recognition, the lack of formal federal recognition means that there is no unified strategy for addressing the issue, no unified definition, reduction targets, or periodic evaluations. Despite the limitations of the Scottish definition, the existence of a clear legislated approach is helpful for setting and evaluating the strategy at a national level.

Fuel Poverty Indicators

Attempting to standardise the drivers of fuel poverty into a small number of categories is challenging. It is noted in the literature that the drivers and exacerbators of fuel poverty transcend national boundaries, being strongly influenced by global pressures such as volatile global oil and gas prices, transnational energy supply, and new carbon markets [27].

Simultaneously, it is noted that local and even individual-level drivers need to be considered to capture the nature of the relationship between fuel poverty and the conditions which expose vulnerability [28,29].

There is a broad acceptance around certain key drivers of fuel poverty defined by Boardman [18] as being low income, domestic energy inefficiency, and energy prices. Fuel poverty can be considered as a household living in an energy-inefficient dwelling and unable to heat their home at an appropriate level of warmth due to insufficient financial resources [25].

These drivers are mirrored in the Scottish Fuel Poverty Act (FPA), which identifies the three criteria from the Boardman definition but adds how energy is used in the home as a final driver. This additional driver refers to behaviours around individual households' energy consumption and seeks to ensure that energy is optimally used. It was noted in the Fuel Poverty Strategy [30] that this is a complex driver to address as there is a high degree of variability depending on individual factors such as income, health, and dwelling characteristics.

The drivers create the conditions that the indicators seek to measure. The question to be answered is how to identify a population (or households) using one or a set of indicators. Therefore, the choice of indicators is essential as it will dictate what is being measured [25]. Using indicators based on an incomplete understanding of fuel poverty is unlikely to address the deep socio-economic, socio-political, and socio-spatial drivers that are outlined in the literature [31].

Indicators for fuel poverty typically fall within three categories: energy expenditure-based indicators with thresholds, subjective self-reported indicators, or consensual social indicators. The Scottish FPA uses an energy expenditure-based indicator with a threshold commonly referred to as the Ten Percent Rule (TPR).

Energy expenditure-based indicators and consensual social indicators are objective indicators of household circumstances [25]. Energy expenditure-based indicators account for the expenditure devoted to satisfying fuel needs with respect to the total income. Consensual social indicators refer to conditions of social exclusion and material deprivation, such as cooking, lighting, education, and communication, whereas subjective self-reported indicators report personal opinions, interpretations, and judgments, such as thermal comfort, trouble paying bills, and satisfaction with energy services.

Under the Scottish FPA, the energy expenditure indicator is the cost associated with a temperature threshold as follows:

> "For households requiring an enhanced heating regime, this would be 23 °C in the living room and 20 °C in other rooms. For other households, this is 21 °C in the living room and 18 °C in other rooms. For a household for which enhanced heating hours is appropriate, heating the home to the requisite temperatures for 16 h a day, every day. For any other household, heating the home to the requisite temperatures for 9 h a day on a weekday and 16 h a day at the weekend."

The TPR is a significant point of contention. As mentioned in the definition, this sets the bar for being 'fuel poor' at above 10% of the household income spent on energy with the caveat that the remaining income is insufficient to meet an acceptable standard of living after certain deductions such as fuel costs, disability or care benefit, and childcare costs. This caveat is important as this is an attempt to limit the definition of fuel poverty to exclude high-income households who have high energy use but have sufficient remaining income to live comfortably.

The TPR is a conceptual application of the Boardman definition [18]; loosely, the same threshold is also used in Wales, Australia, and New Zealand [29]. This threshold was set by doubling the median household energy expenditures based on the 1988 Family Expenditure Survey for UK households.

This twice-median concept was first used when Isherwood and Hancock (1979) introduced the concept of fuel poverty [32]. Even though energy prices have increased faster than the average household income, this twice-median threshold, in place now for more than four decades, has not been updated since [20].

Other iterations of expenditure-based indicators have been used. Until 2021, England and Wales used a relative indicator, namely Low-Income High Cost (LIHC). A household is considered energy poor if it has (a) high energy costs which are above the national median, adjusted for household composition, and (b) low household income, defined as having an income below the sixty per cent median poverty line, adjusted for household size and composition, after deducting energy costs [33]. The LIHC indicator has been heavily criticised as a measure of fuel poverty, as those on lower incomes tend to live in smaller houses and therefore do not meet the 'high cost' threshold set by the indicator [31,34]. Like the TPR, this means that households in energy poverty will not meet the criteria for intervention.

The LIHC was replaced in 2021 by Low-Income Low Energy Efficiency (LILEE), a composite indicator which accounts for income, energy expenditure, and energy efficiency of the dwelling. A household is considered energy poor if they meet the following criteria: (1) they live in a home with a Fuel Poverty Energy Efficiency Rating (FPEER) of less than class C, and (2) after deducting the cost of housing energy service needs, its income is below the poverty line [35,36]. Whilst the LILEE indicator encompasses the main drivers identified by Boardman, it still fails to consider non-expenditure-related vulnerabilities such as mental and physical health or household stress.

Energy-expenditure-based indicators have been shown in micro-simulations to produce misleading or contrary results in identifying vulnerable households [37]. These simulations have both excluded actually vulnerable households and conversely included higher-income households that are not in fuel poverty but have higher relative energy expenditure. Mould and Baker [29] describe this as a failure to understand the complex relationships between fuel poverty and the conditions that may be used to define vulnerability and that a more appropriate indicator for identifying vulnerable households is a risk-based assessment of vulnerability which captures the complex interaction of multiple variables and underlying influences. Iterations of risk-based assessments of vulnerability are a common theme in the literature and draw their meaning from linking fuel poverty to other conditions of vulnerability in a household such as mental and physical health and financial stress. Liddell and Guiney [38] have identified a cycle of risk which associates fuel poverty as incorporating aspects, such as worsened physical health, increased stress, and increased detrimental coping behaviours, e.g., smoking and over-eating. These vulnerabilities both result from and contribute to fuel poverty, and this should be an important consideration in the identification of fuel-poor households.

As an example, poor mental health contributes to and results from fuel poverty. Consequently, interventions involving the health sector would stand to create vast benefits according to a risk-based assessment both in mitigating the impacts of fuel poverty and also in identifying interventions which can help alleviate the energy-specific challenges faced by that household.

In a comparative study of German households, researchers found a correlation between household composition and characteristics, educational attainment, labour force

status, primary energy source, and energy poverty [39]. Furthermore, researchers noted that households who had previously experienced energy poverty were up to 7.5% more likely to experience energy poverty again in the future. The correlation between energy poverty and non-expenditure-based indicators is observed in other industrialised countries as well as Scotland making a case for the consideration of consensual and subjective indicators in the policy approach.

The essence of the objection to the TPR, or any energy expenditure-based indicator with an income threshold, is that it seeks to normalise many variables. For example, behaviour is normalised by assuming a standard heating regime, whilst ignoring other variables with a clear causal link to fuel poverty such as the mental health example presented above. Using this type of indicator, therefore, does not allow the accurate identification of vulnerable households [37].

A further complication is 'hidden fuel poverty', where households will self-adjust or disconnect from utilities entirely as a means of managing their finances. 'Hidden fuel poverty' refers to a situation where a household is self-regulating their energy consumption so that they are living in de facto fuel poverty, i.e., not able to adequately heat their home to the legislated standard, but due to this self-regulation, they are not identified as vulnerable [40]. Social stigma and cultural norms play a role in keeping this hidden from official statistics, meaning that those in fuel poverty will not self-identify. These so-called 'hidden geographies' can often be identified as having lower energy use than their counterparts [41].

Notionally, one can see that there may be huge variability in the costs associated with reaching a temperature threshold as set out in the Scottish FPA based on the type of heating technology, the energy efficiency of the building itself and even the climate where a household is located. Those further north in Scotland will face colder temperatures and less urban infrastructure than those in the south, for example.

By standardising variables which are inherently unique, a study in Northern Ireland of 1595 households found that many of those living in extreme fuel poverty did not qualify for energy efficiency upgrades despite standing to benefit proportionately more than non-fuel-poor counterparts [34]. Eligibility in this study was restricted to vulnerable households as identified by a single indicator; One which has a resident aged over 60, under 16, and/or someone with a disability or long-term limiting illness. The study showed that a single-indicator approach was inappropriate for identifying fuel-poor households due to the highly individual nature of the challenges faced by households and the combination of various factors, such as age, income, health, and characteristics of the property, all contributing to the state of fuel poverty.

The outcome of this approach attempts to fix technical challenges leading to fuel poverty without considering the societal issues. Specifically referencing the Scottish FPA, Mould and Baker [29] identify additional drivers not currently included in any of the mitigation schemes, including debt, poor mental health, poor physical health, and poor educational attainment. Mould and Baker [29], therefore, criticise the Scottish FPA, not on the basis of their inadequacy, but on the eligibility criteria for the application of mitigation programs because they do not consider additional drivers that are crucial.

It is noted in the Scottish Fuel Poverty Strategy, published in 2021 to support the execution of the FPA, that 'needs' are identified as a contributor to household energy vulnerability [30]. While the strategy document mentions other forms of vulnerability which may play a role, it primarily focuses on health as a driver. There is a further recommendation to include consensual indicators in the definition of fuel poverty relating to age (both young children and older people), long-term illness (physical or mental), and/or disability. There are, however, no further updates on this recommendation.

> "These needs-based indicators can be a predictor of a lower income and/or higher energy use which may make a household vulnerable to fuel poverty. Though the strategy document recognises that non-expenditure-related indicators are central in identifying vulnerable households, the act currently makes no provision for using these consensual indicators to do so."

3. Transport Poverty: Foundational Concepts

It is the intention of this paper to bring transport and fuel poverty towards a unified definition, and to do so, we must consider the academic research on transport poverty. Whilst there are some important distinctions between fuel and transport poverty, the transport poverty literature builds on some of the foundation concepts explored above. With the growing concern around climate change driving the energy transition, energy sources typically considered distinct are now coming together. Examples of this include electric heating and electric cars, both being part of the same domestic energy bill.

It is difficult to construct a concise definition for transport poverty as, unlike fuel poverty, transport poverty exists with individuals rather than with a household. One member of a household may experience transport poverty, and others may not [42].

An intuitive example might be a household living in a rural area where due to age-related issues, an elderly person is not able to drive a car and, therefore, must rely on other members of the household to drive them or use public transport, which may not be reliable due to the rural location of the dwelling.

There are countless variations of this scenario, with a common complaint across the literature being the highly individual nature of the conditions exposing transport poverty. This contextual specificity makes vulnerability difficult to identify, particularly if you rely on a single indicator. Despite this highly individual context, there are certain common vulnerabilities explored by the literature, such as being polarised around gender and age [43].

Like fuel poverty, there are expenditure-based indicators which correlate to definitions around transport affordability and mobility poverty (usually centred around a lack of motorised transport). Unlike fuel poverty, the definition needs to also capture the secondary impact of transport poverty; a lack of transport may not necessarily be a problem in itself—the challenge may rather lie in the social exclusion and accessibility challenges that follow.

This secondary impact is highly context-specific to social, temporal, and geographical factors, which means that it is challenging to define a standardised indicator that captures the nuances of the challenge [42]. Transport poverty could notionally be a combination of factors to do with a deficiency in transport supply, and/or to a minimum standard of mobility, and/or a standard of accessibility to goods, services, and daily activities.

Distinguishing between these factors, Lucas et al. [42] propose transport poverty as a combination of the following subset of factors: transport affordability, mobility poverty, accessibility poverty, and exposure to transport externalities.

A brief definition of these terms is as follows:

- Transport affordability is the inability to afford adequate transport;
- Mobility poverty is a lack of motorised transport;
- Accessibility poverty is the difficulty in reaching certain key activities such as employment, education, healthcare, and shops;
- Exposure to transport externalities, where transport poverty can be seen to include the disproportionate negative exposures to the transport system itself, which includes road traffic accidents or health risks associated with emissions.

The definitions emerging in the most recent literature centre around affordability and accessibility, with Lowans et al. offering the following: "the enforced lack of mobility services necessary for participation in society, resulting from the inaccessibility, and/or unaffordability, and or unavailability of transport" [19].

Whilst the policy literature on the topic is relatively young, research on transport accessibility in the U.K. has been prominent since the 1990s. The Social Exclusion Unit study Making Connections in 2003 sought to understand the challenges associated with transport-related social exclusion.

Transport-related social exclusion acknowledges that exclusion is multi-faceted and not driven by a single factor, such as income, and proposes several aspects which can be seen to have mobility components [44]. The definitions broadly emphasise the importance

of transport in facilitating social participation and mobility as a dimension for potential exclusion [45,46].

The Making Connections study firmly established that if people do not have good levels of access to jobs, goods, services, and other essential activities, a lack of adequate transport resources can contribute significantly to social exclusion and feelings of social isolation [47]. The drivers identified in the study are the availability and physical accessibility of transport, cost of transport, services and activities located in inaccessible places, safety and security, and travel horizons.

Mattioli et al. [48] link transport and fuel poverty in terms of correlation and drivers and argue that income, price, and energy efficiency are common drivers to transport and fuel poverty. However, similar to the challenge faced by the accepted concept of fuel poverty, as outlined above, there are nuances when using standardised metrics for an individualised problem.

In order to place transport poverty within the same realm as fuel poverty, Berry et al. [6] draw on the accepted Boardman definition of fuel poverty but propose multidimensional indicators which account for financial resources, fuel consumption and conditions of mobility.

There is broad acceptance for expenditure-based indicators in conjunction with risk-based vulnerability assessments, which consider conditions of mobility relating to individual circumstances.

3.1. Transport Poverty Indicators

As noted above, the challenge with the measurement of transport poverty is the context-specific social, spatial, and geographic factors, which make a single indicator inappropriate. As with the fuel poverty discussion above, it is similarly proposed by the literature that multidimensional indicators be used in an attempt to capture this.

In this section, the indicators of transport poverty, as proposed by the literature, will be discussed alongside the corresponding thresholds.

3.1.1. Affordability

It is clearer in this instance that relying on an expenditure-based indicator is inappropriate, as this does not measure conditions of mobility nor transport-related social exclusion adequately. Income and affordability of transport prominently feature in previous definitions [6,19,44,48].

Relying on the definition of transport poverty proposed by Lucas et al. [42], the indicators proposed consider the dimensions to include mobility, affordability, accessibility, and environmental externalities.

In the U.K. in 2012, the RAC Foundation proposed a ten percent rule similar to that which is seen in the fuel poverty legislation [49]. Similar criticisms about the arbitrariness of this threshold apply. Further criticism is noted with the issue of suppressed need, where households will adjust their transport requirements in line with their income. Unlike the original Boardman TPR, the RAC Foundation based its threshold on current household expenditure. Like the original TPR, a threshold based on current expenditure will also require regular revision to ensure currency.

Furthermore, travel expenditure has been found to be non-regressive, i.e., as household income increases, so too does expenditure on travel [42]. Therefore, it is more likely that richer households will meet the TPR despite lacking need. This is not to say that the application of a qualifier such as that contained in the FPA, that after expenses, the remaining income would be insufficient to meet an acceptable standard of living, but this scenario does clearly illustrate the limitations of affordability as a single indicator.

To overcome the issue of suppressed need, a basic threshold comparable to the temperature/timing standard in the FPA could be proposed to assume a basic amount of travel per household, such as the number of trips per week of a certain distance. The threshold proposed is income, quantity of travel, and single trip fare [50].

3.1.2. Mobility

Mobility poverty in the literature is typically the lack of transportation and mobility options, usually through a lack of individual resources to pay for a car (as an example). Mobility poverty is highly correlated to lower income and has been found to compound driver of poverty.

Lack of access to transport services or infrastructure is certainly a connected issue. However, counterintuitively, Lucas et al. [42] point out that investment in transport infrastructure is not a solution to this challenge as this investment has been found to benefit higher-earning populations while not addressing the issue of mobility poverty for lower-income groups.

The thresholds for mobility poverty have been proposed in different forms. In a recent study surveying energy and transport drivers in Northern Ireland, Lowans et al. [51] propose the metric of the 'essentiality of having a car'. Other metrics proposed include the number of trips, the distance of travel, and commuting times [52–54].

3.1.3. Accessibility

Accessibility poverty is a well-studied area in the U.K., with transport geography studies having viewed transport poverty through the lens of transport-related social exclusion. Transport-related social exclusion refers to people not being able to fully participate in society due to limited access to transport or other barriers to adequate transport access [55].

If transport is understood as a means to satisfy needs, accessibility poverty acts to recreate general conditions of poverty, which has a clear connection to social exclusion [56]. It is clear why this has been a concern of geography scholars, as the link to need establishes a prerequisite for transport planning to take into account access to social services such as shopping, hospitals, and schools.

It should be noted that there is no caveat of necessity typically associated with this, such as whether social engagements are less important than medical appointments.

The metrics proposed for accessibility are transport disadvantage (those in areas with little to no access to transport), availability of public transport, and the difference between transport need and the availability of public transport [57–59].

3.1.4. Negative Externalities

The negative externalities related to transport poverty refer to the disproportionate direct exposure of certain population groups to traffic-related environmental externalities, such as air and noise pollution, as well as traffic-related pedestrian casualties and deaths [42]. With climate concerns driving the reduction in emissions throughout the U.K., exposure to these externalities and the extent to which these are not adequately captured in energy transition policy are prevalent concerns.

A secondary important impact to be measured is the dis-amenities of transport infrastructure projects on the local communities who are living alongside them, as well as the disbanding and dislocation of communities because of building these projects [42]. An example might be the impact of a large motorway project which is built through a neighbourhood.

A set of simple metrics have been proposed for measurement, which are carbon emissions in that neighbourhood, the traffic count, or even the number of traffic-related deaths [42].

4. Towards a Unified Concept: Double Energy Vulnerability

The fuel and transport poverty debates have been disconnected; however, there is growing consensus that these are connected within a broader debate about energy consumption. The rationale includes that transport accounts for a large share of household energy expenditure and climate emissions and that there is often a trade off between household expenditure, suggesting that there is an inherent link between transport and energy expenditure [11]. Considerations of carbon efficiency are an emerging concern in all

energy-related literature, and with net zero ambitions front of mind for the energy sector, these need to be carefully considered within the current debate.

This intersection between fuel and transport poverty is described in the literature as the phenomenon of double energy vulnerability (DEV). DEV is the increased likelihood of negative impacts on well being, owing to the intersection of domestic energy poverty and transport energy poverty [11]. A key characteristic of DEV is that it could force individuals or households to prioritise their expenditure between energy and transport expenditure [60].

DEV mirrors vulnerability in both concepts, for example, single-parent households, those with medical conditions, or households with children and elderly family members. DEV is typically linked to lower income in these households. Those on low incomes can be particularly affected as energy and transport costs take up a greater proportion of their incomes, and they often lack financial resources to invest in the most energy-efficiency measures, appliances or vehicles.

Furthermore, it is postulated that the drivers and outcomes of transport and energy poverty are inherently linked. Therefore, despite the challenges in discerning a unified metric, these should be considered jointly for policy makers to adequately conceive the challenge [19].

Additionally, it is noted across the literature that the numbers of excess deaths resulting directly from fuel and transport poverty are comparable. A report published by the Institute of Health Equity in 2022 noted that of 63,000 excess winter deaths in the U.K., 10% were directly attributable to fuel poverty and 21.5% to cold homes [61]. In terms of transport poverty, Lucas et al. [42] frame this as individuals being forced to rely on options such as walking and cycling, therefore, being exposed to road-related casualties and traffic-related pollutants. In sum, although energy poverty is responsible for cold-housing-related deaths, transport poverty has a comparable number of associated mortality [19], therefore, requiring equal attention from policymakers.

In the context of climate change, the concerns over mortality are amplified as, in addition to the disproportionately high pollution in lower-income neighbourhoods, as noted in the literature [62], there are circumstances where summertime cooling becomes a concern. Though this is arguably less applicable currently as Scotland has a mild climate and does not necessarily have the same concerns for cooling as more Southern geographies, it is not inconceivable that this may be a concern in the future.

With the connection between the drivers for the outcomes of both fuel and transport poverty, there is a strong case for considering the monitoring of these two challenges side-by-side. DEV can be visualised in Figure 1 below, adapted from Simcock et al. [63].

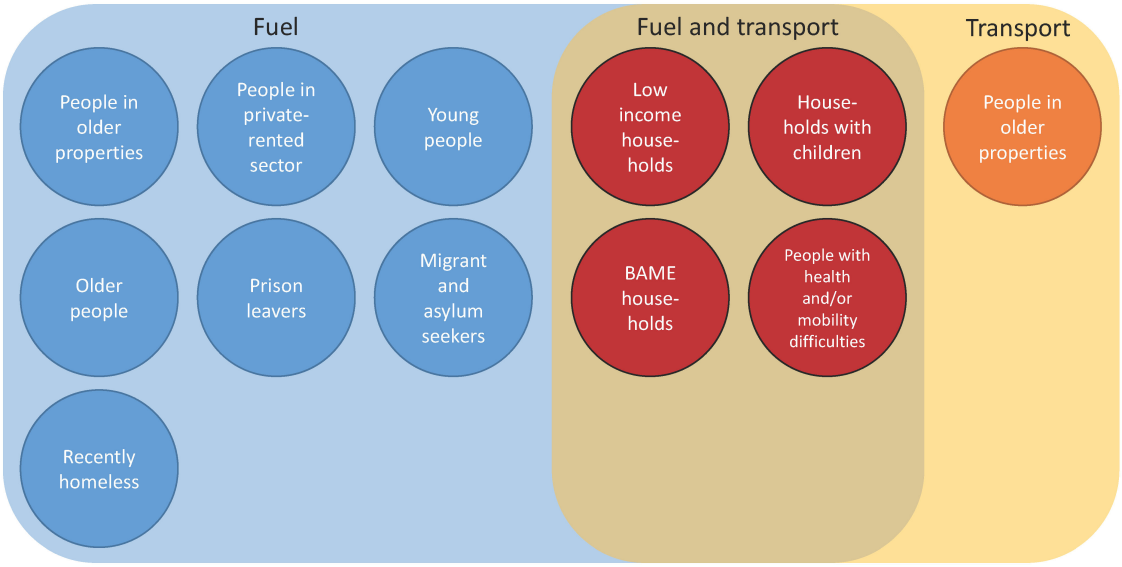

Figure 1. Groups of people identified as potentially vulnerable to fuel, transport and fuel and transport poverty (adapted from [63]).

Figure 1 shows several drivers for fuel and transport poverty and that there are common drivers for both conditions. Simcock et al. [64] postulate that while these may be separate conditions in some respects, there are common underlying drivers, which may justify addressing these conditions together. The overlap is indicated in the red bubbles below.

Although there is broad agreement in the literature that these two concepts are linked, it should be noted that available research has not yet proven the overlap definitively. To correlate transport and energy poverty drivers, Lowans et al. [51] conducted a study which attempted to capture the overlap between energy and transport poverty drivers looking at both energy expenditure-based consumption with a threshold and consensual indicators (arrears in bills, inability to keep warm, essentiality of car ownership, and adequacy of public transport). Although the study did find a statistically significant correlation between the financial drivers, and energy and transport poverty, the authors observe that the correlation is not definitive as it correlated financial drivers to those who are not energy poor and not transport poor, rather than correlating drivers between those that are energy poor and are transport poor. Although the academic community postulate a strong interaction between the drivers of fuel and transport poverty, it remains unproven [11,19,60,64].

The challenge in proving this correlation noted by Lowans et al. [51] is that there is limited monitoring data and no national surveying of actual energy-expenditure data. As a primary policy recommendation, the authors suggest that national monitoring be implemented and monitored alongside a set of transport poverty indicators.

An important further recommendation is that transport and energy poverty be recognised according to any set of indicators depending on the context (e.g., TPR OR risk-based vulnerability OR any other) rather than targeting via a specific set (e.g., TPR only), remarking that a single targeted approach can be a poor policy approach. By broadening the availability of support schemes to alleviate transport and energy poverty beyond the current energy expenditure-based indicators to include consensual indicators, the debate about the inadequacy of indicators in identifying vulnerable households becomes moot.

It is clear from the existing literature that there needs to be a variety of indicators used to identify households in potential fuel and transport poverty. The variation between these constructs and the individual nuances that lead to and stem from fuel and transport poverty is too complex to only use an expenditure-based threshold or consensual indicators.

5. Conclusions

The literature on fuel and transport poverty is growing rapidly, with proven limitations on the definitions, indicators, and thresholds used to identify vulnerable households. The literature shows that the drivers of fuel and transport poverty overlap and that it makes practical sense to consider these challenges under the same policy umbrella. Although there are clear differences in the manifestation of these issues, where a vulnerability-based risk assessment is used to identify vulnerable households, it is possible to address both outcomes. It is further evidence that there is a lack of monitoring data available to consider these challenges in real time, limiting the understanding that exists of how these drivers overlap and, consequently, the best way to address these issues through policy.

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References

1. Energy Action Scotland (EAS). *UK Fuel Poverty*; Energy Action Scotland: Glasgow, UK, 2022.
2. Scottish Government. Fuel Poverty (Targets, Definition and Strategy) (Scotland). 2019. Available online: https://www.parliament.scot/bills-and-laws/bills/fuel-poverty-scotland-bill (accessed on 14 June 2023).
3. van Dülmen, C.; Šimon, M.; Klärner, A. Transport poverty meets car dependency: A GPS tracking study of socially disadvantaged groups in European rural peripheries. *J. Transp. Geogr.* **2022**, *101*, 103351. [CrossRef]
4. Sustrans. Transport Poverty in Scotland. 2016. Available online: https://www.sustrans.org.uk/our-blog/research/all-themes/all/transport-poverty-in-scotland/ (accessed on 22 March 2023).
5. Scottish Government. Just Transition—A Fairer, Greener Scotland: Scottish Government Response. 2021. Available online: https://www.gov.scot/publications/transition-fairer-greener-scotland/ (accessed on 14 June 2023).
6. Berry, A.; Jouffe, Y.; Coulombel, N.; Guivarch, C. Investigating fuel poverty in the transport sector: Toward a composite indicator of vulnerability. *Energy Res. Soc. Sci.* **2016**, *18*, 7–20. [CrossRef]
7. Sovacool, B.K.; Dworkin, M.H. Energy justice: Conceptual insights and practical applications. *Appl. Energy* **2015**, *142*, 435–444. [CrossRef]
8. ONS. Consumer Price Inflation, UK: October 2022. 2023. Available online: https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/consumerpriceinflation/october2022 (accessed on 14 June 2023).
9. Scottish Government. Draft Energy Strategy and Just Transition Plan. 2023. Available online: https://www.gov.scot/publications/draft-energy-strategy-transition-plan/ (accessed on 14 June 2023).
10. Churchill, S.A.; Smyth, R.; Farrell, L. Fuel poverty and subjective wellbeing. *Energy Econ.* **2020**, *86*, 104650. [CrossRef]
11. Robinson, C.; Mattioli, G. Double energy vulnerability: Spatial intersections of domestic and transport energy poverty in England. *Energy Res. Soc. Sci.* **2020**, *70*, 101699. [CrossRef]
12. Charlier, D.; Legendre, B. Fuel poverty in industrialized countries: Definition, measures and policy implications a review. *Energy* **2021**, *236*, 121557. [CrossRef]
13. Kang, L.; Lloyd, B.; Liang, X.-J.; Wei, Y.-M. Energy Poor or Fuel Poor: What Are the Differences? *Energy Policy* **2014**, *68*, 476–481. [CrossRef]
14. Baker, K.J.; Mould, R.; Restrick, S. Rethink Fuel Poverty as a Complex Problem. *Nat. Energy* **2018**, *3*, 610–612. [CrossRef]
15. Isherwood, B.C.; Hancock, R.M. *Household Expenditure on Fuel: Distributional Aspects*; Economic Adviser's Office, DHSS: London, UK, 1979.
16. Primc, K.; Dominko, M.; Slabe-Erker, R. 30 years of energy and fuel poverty research: A retrospective analysis and future trends. *J. Clean. Prod.* **2021**, *301*, 127003. [CrossRef]
17. Castaño-Rosa, R.; Sherriff, G.; Thomson, H.; Guzmán, J.S.; Marrero, M. Transferring the index of vulnerable homes: Application at the local-scale in England to assess fuel poverty vulnerability. *Energy Build.* **2019**, *203*, 109458. [CrossRef]
18. Boardman, B. *Fuel Poverty: From Cold Homes to Affordable Warmth*; Pinter Pub Limited: London, UK, 1991.
19. Lowans, C.; Del Rio, D.F.; Sovacool, B.K.; Rooney, D.; Foley, A.M. What is the state of the art in energy and transport poverty metrics? A Critical and Comprehensive Review. *Energy Econ.* **2021**, *101*, 105360. [CrossRef]
20. Robinson, C.; Bouzarovski, S.; Lindley, S. Underrepresenting neighbourhood vulnerabilities? The measurement of fuel poverty in England. *Environ. Plan. A Econ. Space* **2018**, *50*, 1109–1127. [CrossRef]
21. Papada, L.; Kaliampakos, D. Measuring energy poverty in Greece. *Energy Policy* **2016**, *94*, 157–165. [CrossRef]
22. Papada, L.; Kaliampakos, D. Being forced to skimp on energy needs: A new look at energy poverty in Greece. *Energy Res. Soc. Sci.* **2020**, *64*, 101450. [CrossRef]
23. Castaño-Rosa, R.; Solís-Guzmán, J.; Rubio-Bellido, C.; Marrero, M. Towards a multiple-indicator approach to energy poverty in the European Union: A review. *Energy Build.* **2019**, *193*, 36–48. [CrossRef]
24. Aristondo, O.; Onaindia, E. Inequality of energy poverty between groups in Spain. *Energy* **2018**, *153*, 431–442. [CrossRef]
25. Fizaine, F.; Kahouli, S. On the power of indicators: How the choice of fuel poverty indicator affects the identification of the target population. *Appl. Econ.* **2019**, *51*, 1081–1110. [CrossRef]
26. Bednar, D.J.; Reames, T.G. Recognition of and response to energy poverty in the United States. *Nat. Energy* **2020**, *5*, 432–439. [CrossRef]
27. Thomson, H.; Snell, C. Quantifying the prevalence of fuel poverty across the European Union. *Energy Policy* **2013**, *52*, 563–572. [CrossRef]
28. Liddell, C.; Morris, C.; McKenzie, P.; Rae, G. Defining Fuel Poverty in Northern Ireland: A Preliminary Review. 2011. Available online: https://pure.ulster.ac.uk/en/publications/defining-fuel-poverty-in-northern-ireland-a-preliminary-review-3 (accessed on 14 June 2023).
29. Mould, R.; Baker, K.J. Documenting fuel poverty from the householders' perspective. *Energy Res. Soc. Sci.* **2017**, *31*, 21–31. [CrossRef]

30. Scottish Government. Tackling Fuel Poverty in Scotland: A Strategic Approach. 2021. Available online: https://www.gov.scot/publications/tackling-fuel-poverty-scotland-strategic-approach/ (accessed on 14 June 2023).
31. Thomson, H.; Bouzarovski, S.; Snell, C. Rethinking the measurement of energy poverty in Europe: A critical analysis of indicators and data. *Indoor Built Environ.* **2017**, *26*, 879–901. [CrossRef] [PubMed]
32. Liddell, C.; Morris, C.; McKenzie, S.J.P.; Rae, G. Measuring and monitoring fuel poverty in the UK: National and regional perspectives. *Energy Policy* **2012**, *49*, 27–32. [CrossRef]
33. UK Government. *Fuel Poverty Methodology Handbook (Low Income High Costs)*; Department for Energy Security and Net Zero: London, UK, 2020. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/966521/Fuel_Poverty_Methodology_Handbook_2020_LIHC.pdf (accessed on 14 June 2023).
34. Walker, R.; Liddell, C.; McKenzie, P.; Morris, C.; Lagdon, S. Fuel poverty in Northern Ireland: Humanizing the plight of vulnerable households. *Energy Res. Soc. Sci.* **2014**, *4*, 89–99. [CrossRef]
35. UK Government Department for Business, Energy & Industrial Strategy. Fuel Poverty Methodology Handbook (Low Income Low Energy Efficiency). 2022. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1138926/fuel-poverty-methodology-handbook-lilee-2023.pdf (accessed on 14 June 2023).
36. Belaïd, F. Implications of poorly designed climate policy on energy poverty: Global reflections on the current surge in energy prices. *Energy Res. Soc. Sci.* **2022**, *92*, 102790. [CrossRef]
37. Peter, H.; Schuessler, R. Dynamic Properties of Energy Affordability Measures. *Energy Policy* **2015**, *86*, 123–132. [CrossRef]
38. Liddell, C.; Guiney, C. Living in a cold and damp home: Frameworks for understanding impacts on mental well-being. *Public Health* **2015**, *129*, 191–199. [CrossRef]
39. Drescher, K.; Janzen, B. Determinants, persistence, and dynamics of energy poverty: An empirical assessment using German household survey data. *Energy Econ.* **2021**, *102*, 105433. [CrossRef]
40. Faiella, I.; Lavecchia, L.; Miniaci, R.; Valbonesi, P. *Household Energy Poverty and the "Just Transition"*; Springer: Cham, Switzerland, 2022.
41. Mould, R.; Baker, K.J. Uncovering hidden geographies and socio-economic influences on fuel poverty using household fuel spend data: A meso-scale study in Scotland. *Indoor Built Environ.* **2017**, *26*, 914–936. [CrossRef]
42. Lucas, K.; Mattioli, G.; Verlinghieri, E.; Guzman, A. Transport poverty and its adverse social consequences. *Proc. Inst. Civ. Eng. Transp.* **2016**, *169*, 353–365. [CrossRef]
43. Booth, D.; Hanmer, L.; Lovell, E. Poverty and transport. In *Report for the World Bank*; Overseas Development Institute: London, UK, 2000.
44. Church, A.; Frost, M.; Sullivan, K. Transport and social exclusion in London. *Transp. Policy* **2000**, *7*, 195–205. [CrossRef]
45. Gaffron, P.; Hine, J.; Mitchell, F. *The Role of Transport in Social Exclusion in Urban Scotland*; Scottish Executive: Glasgow, UK, 2001.
46. Kenyon, S.; Rafferty, J.; Lyons, G. Social exclusion and transport in the UK: A role for virtual accessibility in the alleviation of mobility-related social exclusion? *J. Soc. Policy* **2003**, *32*, 317–338. [CrossRef]
47. Social Exclusion Unit. Making the Connections: Final Report on Transport and Social Exclusion. 2003. Available online: http://webarchive.nationalarchives.gov.uk/+/http://www.cabinetoffice.gov.uk/media/cabinetoffice/social_exclusion_task_force/assets/publications_1997_to_2006/making_transport_2003.pdf (accessed on 14 June 2023).
48. Mattioli, G.; Lucas, K.; Marsden, G. Reprint of Transport poverty and fuel poverty in the UK: From analogy to comparison. *Transp. Policy* **2018**, *65*, 114–125. [CrossRef]
49. RAC Founderation. 21 Million Households in Transport Poverty. 2012. Available online: https://www.racfoundation.org/media-centre/transport-poverty (accessed on 14 June 2023).
50. Carruthers, R.; Dick, M.; Saurkar, A. *Affordability of Public Transport in Developing Countries*; Transport Papers, TP-3; The World Bank Group: Washington, DC, USA, 2005; pp. 1–27.
51. Lowans, C.; Foley, A.; Del Rio, D.F.; Caulfield, B.; Sovacool, B.K.; Griffiths, S.; Rooney, D. What causes energy and transport poverty in Ireland? Analysing demographic, economic, and social dynamics, and policy implications. *Energy Policy* **2023**, *172*, 113313. [CrossRef]
52. Schmöcker, J.D.; Quddus, M.A.; Noland, R.B.; Bell, M.G. Estimating trip generation of elderly and disabled people: Analysis of London data. *Transp. Res. Rec.* **2005**, *1924*, 9–18. [CrossRef]
53. Morency, C.; Paez, A.; Roorda, M.J.; Mercado, R.; Farber, S. Distance traveled in three Canadian cities: Spatial analysis from the perspective of vulnerable population segments. *J. Transp. Geogr.* **2011**, *19*, 39–50. [CrossRef]
54. McQuaid, R.W.; Chen, T. Commuting times–The role of gender, children and part-time work. *Res. Transp. Econ.* **2012**, *34*, 66–73. [CrossRef]
55. Kamruzzaman, M.; Yigitcanlar, T.; Yang, J.; Mohamed, M.A. Measures of transport-related social exclusion: A critical review of the literature. *Sustainability* **2016**, *8*, 696. [CrossRef]
56. Lucas, K. Transport and social exclusion: Where are we now? *Transp. Policy* **2012**, *20*, 105–113. [CrossRef]
57. Currie, G. Gap analysis of public transport needs: Measuring spatial distribution of public transport needs and identifying gaps in the quality of public transport provision. *Transp. Res. Rec.* **2004**, *1895*, 137–146. [CrossRef]
58. Delmelle, E.C.; Casas, I. Evaluating the spatial equity of bus rapid transit-based accessibility patterns in a developing country: The case of Cali, Colombia. *Transp. Policy* **2012**, *20*, 36–46. [CrossRef]
59. Jaramillo, C.; Lizárraga, C.; Grindlay, A.L. Spatial disparity in transport social needs and public transport provision in Santiago de Cali (Colombia). *J. Transp. Geogr.* **2012**, *24*, 340–357. [CrossRef]

60. Sovacool, B.K.; Del Rio, D.D.F. "We're not dead yet!": Extreme energy and transport poverty, perpetual peripheralization, and spatial justice among Gypsies and Travellers in Northern Ireland. *Renew. Sustain. Energy Rev.* **2022**, *160*, 112262. [CrossRef]
61. Lee, A.; Sinha, I.; Boyce, T.; Allen, J.; Goldblatt, P. *Fuel Poverty, Cold Homes and Health Inequalities*; Institute of Health Equity: London, UK, 2022.
62. Mitchell, G.; Dorling, D. An environmental justice analysis of British air quality. *Environ. Plan. A* **2003**, *35*, 909–929. [CrossRef]
63. Simcock, N.; Jenkins, K.; Mattioli, G.; Lacey-Barnacle, M.; Bouzarovski, S.; Martiskainen, M. *Vulnerability to Fuel and Transport Poverty*; Centre for Research into Energy Demand Solutions: Oxford, UK, 2020.
64. Simcock, N.; Jenkins, K.E.; Lacey-Barnacle, M.; Martiskainen, M.; Mattioli, G.; Hopkins, D. Identifying double energy vulnerability: A systematic and narrative review of groups at-risk of energy and transport poverty in the global north. *Energy Res. Soc. Sci.* **2021**, *82*, 102351. [CrossRef]