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Assessing the fuel poverty vulnerability of urban neighbourhoods using a spatial multi-criteria decision analysis for the German city of Oberhausen

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ABSTRACT

Tackling fuel poverty has become an increasingly important issue on many European countries' political agendas. Consequently, national governments, local authorities and NGOs have established policies and programmes to reduce the fuel poverty vulnerability of households. However, evaluations of such policies and programmes show that they barely reach those who are most in need. The reasons for this failure are diverse and include fuel poverty measurement metrics, local scale data availability and policy design. This raises the question of how fuel poor homes can be more effectively identified and targeted to ensure that limited local and national budgets are used to benefit those who most need help.

Area-based approaches, which pinpoint spatial units highly affected by fuel poverty due to their specific characteristics, offer an opportunity for creating more tailored policies and programmes. In this study, the author developed a GIS-MCDA (Multi-Criteria Decision Analysis), using an AHP (Analytical Hierarchy Process) and applied the approach to the German city of Oberhausen. The overall issue of fuel poverty was broken down into three vulnerability dimensions (heating burden, socio-economic and building vulnerability), the relative importance of fuel poverty criteria and the dimensions were evaluated by experts, and an overall Fuel Poverty Index was created to assess the relative fuel poverty vulnerability of 168 urban neighbourhoods.

The analysis offers insights into the spatial pattern of fuel poverty within a city and thus provides an opportunity to channel efforts towards households in those neighbourhoods most in need. It also demonstrates that a trade-off between ecological and social targets should be considered in the development of future policies for tackling fuel poverty.

1. Introduction

Fuel poverty has become an increasingly important issue at EU level and in several member states [1,2]. A growing number of policy packages are in place to tackle fuel poverty [1,3] and research into the subject has intensified over the past year. While the UK serves as a pioneer in fuel poverty research, with more than 20 years of experience [4,5], research has only taken place in other European countries in recent years. Analyses exist for France [6,7], Greece [8–10], Slovakia [11], Portugal [12], Austria [13], Belgium [14], Italy [15,16] and Denmark [17], and initiatives such as the Fuel Poverty Network and the European Energy Poverty Observatory (EPOV) facilitate dialogue between relevant stakeholders to identify and resolve fuel poverty issues. Several studies have also been undertaken in Germany [18–24] and the Federal Ministry of Education and Research encourages discussion about fuel poverty as part of its "Research for Sustainable Development" agenda; however, the issue has long been almost a "blank spot" on the German research agenda [25].

There are many reasons why greater attention is being paid to fuel poverty and these reasons differ from country to country. A key issue is the growth in fuel prices; in Germany, for example, household expenditure on heating oil (+ 230%), natural gas (+ 100%) and electricity (+ 80%) has increased significantly over the last two decades (1994–2014) [26]. This development not only puts pressure on low income households, those living in energy inefficient homes or with disproportionate energy needs; it also compels policymakers to develop strategies for tackling fuel poverty because fuel poverty creates a number of costs for both the individual and society. Studies indicate that cold and uncomfortable homes negatively affect physical health and mental wellbeing [27] and in the worst cases can cause premature death [28,29]. Fuel poverty reduces living standards and the everyday habits of those living in fuel poor homes and can contribute to social exclusion [13,30].

Consequently, national governments, local authorities and NGOs have implemented policies and programmes to reduce fuel poverty. However, evaluations of such policies and programmes show that they

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barely reach fuel poor homes [31] or, as Boardman [74] concluded, "policy has been poorly targeted, resulting in high levels of misspent money, often more than three-quarters of the money in a fuel poverty policy failing to reach the fuel poor". Against the background of limited local and national budgets, this finding raises the question of how fuel poor homes can be more effectively identified and targeted to ensure that funds are used to benefit those who most need help. To examine this issue, the author provides an overview of existing fuel poverty measurements and their limitations in targeting fuel poor homes. This study uses an area-based approach, assessing neighbourhoods in terms of their fuel poverty vulnerability. Therefore main driving forces of fuel poverty were identified and their relative impact was assessed using a GIS-MCDA. In contrast to existing policies and programmes, which measure fuel poverty at individual level, this approach assesses the fuel poverty vulnerability of neighbourhoods in terms of their specific characteristics. This not only offers an interesting insight into the spatial distribution of fuel poverty within a city, but also provides the opportunity to tailor policies and actions to those neighbourhoods most in need.

2. Measuring fuel poverty and its limitations

2.1. Macro scale measurements

Measuring fuel poverty is a challenging task. It is a multi-dimensional phenomenon that varies according to time and place, depends on individual household conditions (e.g. household income and characteristics, specific energy needs etc.) as well as external conditions (e.g. energy prices, energy efficiency performance of the building) and is subjectively perceived by individuals [32]. Moreover, measurement metrics depend on the task in hand. At national or EU level, measurement determines the scale and nature of the problem and facilitates the monitoring of progress – but these approaches can be unsuitable for identifying fuel poor homes within streets, neighbourhoods or cities [33].

On a macro scale, there is extensive debate about how to measure fuel poverty [32,34]. There are two main approaches: expenditure-based and consensual-based. Expenditure-based metrics explore fuel poverty as the ratio between household income and energy expenditure and thus measure the affordability of energy services based on objective data. Households whose income/energy expenditure ratio is above a set threshold are considered to be fuel poor. Expenditure-based approaches have been applied and tested in several countries [32]. In contrast, consensual approaches measure fuel poverty based on subjective assessments about a household's ability to adequately warm its home and pay the energy bills on time. Here, self-reported indicators are used to explore perceived fuel poverty, which makes this approach less complex in terms of data collection. Consensual metrics are widely used for pan-European quantification because the EU-SILC survey provides a comparable dataset for EU member states [2,35]. The two approaches have different limitations in terms of both their analytical metrics and their ability to act as guiding principles for the development of policies to identify and target fuel poor homes.

2.2. Metrics-related limitations of the existing measurements

Expenditure-based approaches have several metrics-related limitations. Setting a threshold, for instance, is always normative and results from political negotiations (based on academic recommendations). Moreover, a relative or absolute threshold has different implications for policies. The UK's long-used 10% threshold is a typical example of an absolute threshold, as it measures the absolute amount of household income spent on energy [4]. However, the 10% threshold has been criticised because of its volatility in the face of changes in fuel prices [36]. Recently, England and Wales moved from an absolute threshold to a relative threshold, using the Low Income High Costs (LIHC) indicator. This defines a household as fuel poor if a) it has high energy costs above the national median; and b) it has low household income, which is defined as income below the 60% median poverty line [36,37]. However, this relative threshold has also been criticised because it can mask the impact of increasing energy prices and complicates the monitoring of the effect of political interventions [33]. Another criticism arises from the calculation of energy expenditure. Actual expenditure can be easily collected via household surveys; however, Liddell et al. [38] pointed out that low income households have a particular tendency to reduce their energy needs in order to cope with limited budgets, energy inefficient homes and increases in fuel prices, which makes actual fuel expenditure a poor indicator [32]. The use of calculated energy costs is, therefore, more appropriate when assessing fuel poverty [33] – but this calculation requires detailed knowledge of the energy efficiency performance of the building stock, which is rarely available anywhere else except in the UK [33,35]. Furthermore, modelling energy consumption always involves assumptions about heating patterns[1] and occupancy[2], which can contribute to incorrect estimations. Finally, the way in which household income is measured is also controversial. Three points must be taken into consideration: firstly, whether income should be adjusted according to household size for the purposes of measurement; secondly, whether income is measured before or after housing costs; and thirdly, whether social benefits (e.g. disability benefits) should be included in household income calculations [27,33].

Although consensual approaches require less complex data collection and measurement algorithms, they also have several limitations. Firstly, a household's own assessment is highly subjective. This can contribute to the inclusion/exclusion issues mentioned below if a household *perceives* that it cannot keep its home adequately warm, although it can *objectively* do so (and vice versa). Secondly, the understanding of "adequacy of warmth" as asked in the EU-SILC survey is culturally specific and can differ between regions, countries etc. [2]. Finally, Thomson and Snell [35] pointed out that the widely used EU-SILC dataset was not originally designed to measure fuel poverty and the indicators used are only binary, which does not allow for a discussion about the severity of fuel poverty.

2.3. Limitations of the existing measurements in terms of their ability to act as guiding principles for identifying and targeting fuel poor homes

A clear definition and an appropriate measurement of fuel poverty are crucial for understanding the dimension of fuel poverty and for monitoring progress [1]. The metrics-related limitations outlined above demonstrate that further research is required, because different measurements can produce very different results. Heindl [19], for instance, applied several expenditure approaches for Germany, which produced a wide variation in the results – the share of fuel poor homes varied between 2.4% and 29.8%. In the UK, the change from the long-used 10% poverty line to the LIHC indicator significantly reduced the challenge of fuel poverty virtually overnight. Moreover, different metrics not only influence the number of homes identified as suffering from fuel poverty, but also produce different results concerning the characteristics of those households most in need. Palmer et al. [40], using the English Housing Condition Survey from 2005, compared the results of the objective expenditure-based 10% poverty line with the subjective assessment of the household and found little overlap. Only 6% of the households in fuel poverty according to the objective

[1] In Scotland, the average living room temperature for households comprising the elderly and infirm is 23°C, as opposed to 21°C in England [27,33].

[2] Todd [39] analyses the use of dwellings by households from different cultural backgrounds. The authors demonstrated that different cultural and traditional habits affect the number of rooms regularly used and heated, a fact that is hardly recognised in software calculating energy demand [39].