Modelling Required Energy Consumption with Equivalence Scales

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Energy consumption is necessary for an acceptable quality of life. However, energy consumption also contributes to household expenses. Therefore, when households are poor, energy consumption may be compromised for other purchases. In other words, there is a concern that a non-negligible proportion of the world population is not able to purchase enough reliable energy for their needs and are therefore energy poor. However, although 'enough reliable energy' is understood at an intuitive level, it is necessary to estimate 'need', in order to determine if enough is available.

In the literature, need is based on required energy consumption (REC), which is often debated and remains difficult to estimate. One modelling approach focuses on energy demand, underpinned by engineering methods. These rely on detailed data related to domestic energy usage (in kWh), appliances and/or building characteristic. One such example is the United Kingdom's Building Research Establishment Domestic Energy Model (BREDEM). The BREDEM requires extensive engineering calculations that are localized to account for dwelling characteristics and energy usage. Such detailed data is not widely available, or even available at all in many countries. Another modelling approach is underpinned by purposive surveys that incorporate the relevant aspects of energy usage; however, such surveys are expensive to conduct, and, therefore, difficult to replicate widely. A further approach uses actual energy expenditure, instead of required. Although actual expenditure is expected to capture localized conditions and differences across households, it is unlikely to correctly capture need, because some households will reduce energy consumption to fulfill other needs.

This research develops a method for the determination of required energy consumption that: (i) is underpinned by readily available data, (ii) accounts for household heterogeneities, (iii) captures localized conditions and (iv) incorporates relevant aspects of energy usage. Our method is underpinned by equivalence scales, and makes use of income and expenditure data, which is available in most countries around the world. Thus, our method is especially useful, when detailed engineering energy modelling and usage data are not available, as is the case in most developing country contexts. Specifically, we use semiparametric regression - a nonlinear multivariate regression paying attention to potential endogeneities via control functions - to incorporate a range of both household characteristics and energy usage factors into a model of household energy shares, and we use the estimates from that model to determine the household's energy equivalence scale. We use that scale to adjust a baseline energy consumption value, and determine household required energy consumption.

We apply the method in a case study of South Africa. We find estimated required energy consumption values for low- and mid-income households to be well above their actual energy expenditure. We also find that required expenditure is below actual expenditure for upper-income households. Each of these results is intuitively appealing, because South Africa is an unequal country, where poverty is rife; thus, we would expect poor households to require more energy than they are

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currently using. We further find that required energy expenditure is nearly independent of household expenditure, which is also appealing, as required energy expenditure should capture need, rather than the ability to purchase.

The proposed method offers policymakers a fairly easy way to determine household energy requirements, as well as potential energy subsidies/taxes that could be applied differentially. Importantly, those requirements would be based on local circumstances, rather than on the circumstances that were relevant to the UK or even South Africa. The method can offer researchers and policymakers more accurate comparisons, if they are interested in comparing domestic energy consumption across regions, since our adjustment allows for the incorporation of regional heterogeneity. Importantly, the definition of baseline energy is flexible, and can be adjusted to suit policy goals; for example, one might be interested in subsidizing solar water heating, as that is an important driver of energy consumption.

Furthermore, since our method offers a way to estimate required energy, it offers a way forward, when it comes to energy poverty measurement, which is usually defined for required energy rather than actual. Such information can also help policymakers identify and more efficiently target subsidies to the benefit of households that are energy poor, and thus, mitigate energy poverty.