



Towards a multidimensional framework for measuring household energy access: Application to South Africa



Louise Tait

Energy Research Centre, University of Cape Town, South Africa

ARTICLE INFO

Article history:

Received 9 December 2016

Revised 30 January 2017

Accepted 30 January 2017

Available online xxxx

Keywords:

Energy access
measurement frameworks
South Africa

ABSTRACT

Debate continues around appropriate metrics to measure energy access for the poor. Whilst the underlying principles of energy access, for example affordability or safety, may be universal, the ways in which we define or measure these may vary across different regions. Much of the literature on metrics focuses on standardisation of measures that can have universal applicability. Whilst important for the international community, there is also a need to develop metrics that reflect contextual specificities to be useful to in-country stakeholders. This study has sought to develop a multi-dimensional framework of indicators, with the focus on how to operationalise these in contextually distinct ways that respond to local issues. A framework is developed representing four key dimensions: fuel use, affordability, safety and reliability. The paper offers methodological insights into the development of each and they are developed for the South African context. This illustrates the ways in which a particular context influences both how an indicator is conceptualised, as well as the choice of methods to operationalise it. Indicators aim to be responsive to, and informed by, localised factors such as the particular energy user and supply contexts, the policy environment and data availability.

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Introduction

Energy is a crucial input into social and economic development. Internationally there is more focus than ever on achieving universal access, as seen in the UN's Sustainable Development Goals (SDGs) inclusion of the goal to ensure access to affordable, reliable, and sustainable energy for all. Measuring progress thereon is crucial. But consensus around appropriate metrics remains outstanding. Delineating 'energy poverty' or 'access to modern energy services' is a complex and contested matter. Although various definitions, and their associated critiques, exist, a definitive framing remains outstanding (Serwaa Mensah et al., 2014; Bhanot and Jha, 2012; Bhattacharyya, 2012; Bazilian et al., 2010). The debates in the literature demonstrate many of the features of what Gallie (1956) first referred to as an 'essentially contested concept'. This term refers to situations where, despite widespread agreement about the existence of a concept, further definition or conceptualisation is disputed. Such concepts are characterised as being internally complex in character, subject to modification in light of changing circumstances, and involving value-judgements with different users of the concept allocating different weightings to its constituent elements (Gallie, 1956).

One of the key challenges of measuring energy access lies in operationalising a concept that is inherently multidimensional and, to

a large extent, contextually defined (Groh et al., 2016; Sovacool et al., 2012; Pachauri and Spreng, 2011). Perhaps because of this complexity, many metrics remain dominated by supply side indicators such as access to an electricity connection or a modern stove. These are useful and necessary, but there is broad acknowledgement of the need to augment them with an understanding of the energy services they provide and how these are used (Bhanot and Jha, 2012; Sovacool, 2011; Practical Action, 2013; Nussbaumer et al., 2012; ESMAP, 2015). Shifting this emphasis is probably best illustrated by the definition of energy poverty as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe, and environmentally benign energy services to support economic and human development" (Reddy, 2000:44).

Energy access, as a concept or a target to be achieved, is relatively defined. It is shaped by a variety of contextual factors, including geography, economics and culture. But many frameworks place a strong emphasis on standardising the ways in which we understand and measure access across all contexts. Whilst not disputing the usefulness of international metrics that enable cross-country comparability and target setting, universally set thresholds often end up producing information that is neither appropriate nor useful to country level stakeholders. To suppose that we can establish universality in what is affordable across all countries is perhaps misguided. This article seeks to shift the emphasis away from pursuing common standardised thresholds, towards indicators that can be flexibly developed depending on context, audience and purpose.

E-mail address: louise.tait@uct.ac.za.

Consensus on common methodological approaches is, however, far from conclusive. What is clear from the diverse literature on the subject is that while there may be some agreement on *what* to measure, for example 'safety' or 'affordability', *how* to measure such concepts remain contested. The concept of affordability, although undisputed in terms of its importance, has reached no real consensus in the energy poverty literature on a sound methodological approach to measure it. Likewise 'energy safety' – despite often being a primary justification for energy access initiatives, is often absent in measurement frameworks or dealt with in a very cursory manner. The paper presents a framework of four indicators to conceptualise and measure household energy access. It discusses methods to operationalize each dimension and demonstrates the development of each indicator applied to the South African context, in order to illustrate the importance of contextual input into indicator choice and operationalisation. Various contextual specificities shape what needs to be communicated, the institutional context and policy priorities, as well as the quality and availability of data. These considerations influence what indicators to use and how to construct them. Measurement frameworks for country-level application will always, to some extent, be contextually defined. The focus of this paper is on household uses of energy and does not consider measuring energy for productive uses. Although this is also an important consideration, it is outside the scope of this paper.

The paper is structured as follows. Section 2 reviews the literature to gain an overview of existing approaches to defining and measuring energy access. These conceptual schemes are then used to develop a measurement framework for this study that is presented in section 3. Section 4 then presents a more detailed discussion of the development of each indicator, describing methods and presenting the results of their application to two poor settlements that were surveyed in Cape Town, South Africa. This indicator development aims to critique existing methodologies, and describes some of the issues related to data constraints, adapting measurements to reflect local conditions and defining and setting of thresholds. Finally Section 5 discusses the overall framework results in light of previous debates on methods, frameworks and measurement challenges.

A review of approaches to measuring energy access

Energy is a means rather than an end in itself. What is of importance is less the service itself than the human development outcomes that are theorised to be associated with its use. These can include improved health, wellbeing, education, etc. Measuring these outcomes is, however, a complex undertaking. To measure attribution, one must identify causal mechanisms and control for other contextual factors that may also influence outcomes (Rogers, 2008). Development is, however, a non-linear process, and is typically influenced by a vast number of environmental and other factors (Bazilian et al., 2010). Not surprisingly, such studies measuring outcomes, although they do exist, are limited (Pachauri and Spreng, 2011). Whilst not disputing the importance of understanding these, it may not be realistic to cost-effectively measure and monitor outcomes at large scale.

The dominant framing used to conceptualise and measure energy access has traditionally been from the supply side. Indicators relate to the penetration rates of 'modern' or commercial fuels or end-user technologies (Pachauri and Spreng, 2011). Nussbaumer et al.'s (2012) multi-dimensional energy poverty index (MEPI), for example, measures access to cooking and lighting by the types of fuels used and appliance ownership. These types of supply indicators provide essential information in a simple and easily communicable way that enables comparability across regions, but they are also limited in what they convey. They do not, for example, tell us about the quality of services that users actually derive. They cannot illustrate where poor supply reliability compromises the use of electricity services, nor where on-going usage of biomass fuels may continue in conjunction with electricity use, offsetting the intended health benefits of electrification.

Energy poverty encapsulates multiple dimensions such as consumption, affordability and service quality. Measuring these aspects is, however, substantially more challenging than measuring supply. Defining consumption levels that meet basic needs is inherently complex and is both geographically and temporally influenced. No definitive consensus exists on basic needs thresholds for food for example, nor on what energy consumption levels would be required to provide for those at a household level (Pachauri and Spreng, 2011; IEA, 2012). Any definition of basic needs necessarily involves a degree of subjectivity and value judgements (Pachauri, 2011; Bhanot and Jha, 2012).

There are energy access measures that do attempt to set thresholds for consumption. The IEA's (2012) definition of energy access uses regional average electricity consumption as a benchmark to measure appropriate consumption levels. Barnes et al. (2011) estimate an energy consumption poverty line based on surveys of existing demand profiles of households. Both of these assume that the regional average or existing demand represents an adequate amount of consumption. Practical Action (2010) proposed minimum thresholds for energy services themselves, specifying desired indoor ambient temperatures, lumens of light required, fuel for cooking etc. Cultures, climates and socioeconomic factors can, however, all influence these, implying that standardised thresholds developed in one context many not be transferable to another. These thresholds are also dynamic over time as incomes and/or aspirations change (Bhattacharyya, 2012). Energy access cannot be understood as something a household either has or doesn't have, but is rather a continuous and dynamic process over time, with various dimensions and intermediate 'states' of access (Practical Action, 2013). It might best be understood as a process of increasing the energy consumed over time and the quality of fuels and appliances used. The appropriateness of static thresholds will therefore always be somewhat limited, and yet of course, they are still necessary. Trade-offs exist in taking different approaches in terms of what information one would like to convey and practical considerations. These approaches are more onerous in terms of the cost and practicality of measuring and collecting data, and often the reason supply-side data, easier to capture and monitor continues to dominate metrics (Bazilian et al., 2010).

Reddy (2000) put forward a definition of energy access in the UNDP's World Energy Assessment report that places the focus firmly on the energy service itself and the desired attributes it should encompass. These include safety, affordability, reliability, user adequateness and environmental considerations. This conceptualisation of modern energy services has found wide support and is reiterated in many studies (Bhanot and Jha, 2012; Pachauri, 2011; Sovacool, 2011; Bhattacharyya, 2012; ESMAP, 2015; Gonzalez-Eguino, 2015). It is notably neutral on fuel or technology, but rather places attention on the attributes of the services that people derive from different fuel/technology combinations.

One of the most notable contributions towards operationalizing this definition is in the recent multi-tier tracking framework developed by ESMAP in the Sustainable Energy for All's Global Tracking Framework report (ESMAP, 2015). Consisting of several measurement frameworks measuring electricity and cooking services, the attributes framework measures capacity, availability, reliability, quality, affordability, legality, convenience, and health and safety for electricity, cooking and heating services. This approach to measuring energy services has many distinct advantages. It is multi-dimensional and brings into focus the various inter-related factors that influence 'access'. Scores for each are measured on a continuum of different thresholds specified in tiers, rather than with a single binary threshold. It also captures important aspects related to quality – a dimension typically absent in most metrics (Bazilian et al., 2010).

The operationalisation of some of the indicators in this framework do not, however, have a coherent conceptual or methodological grounding. The safety indicator for example is measured by past accidents and perceptions of future risk by householders (ESMAP, 2015). This offers

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